U. S. Atomic Energy Commission

Docket No. 50-286

Exhibit B-2

Regulatory Suppl File Cy.

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

INDIAN POINT NUCLEAR GENERATING UNIT NO. 3

SECOND SUPPLEMENT TO:

PRELIMINARY SAFETY ANALYSIS REPORT

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Docket No. 50-286

Exhibit B 3

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3

THIRD SUPPLEMENT TO:
PRELIMINARY SAFETY ANALYSIS REPORT

PREFACE

The following listing of material furnished as Supplement No. 3 will serve as a check list for entering new pages into Supplment No. 2 to the PSAR.

The listing shows the original pages and the replacement or addition pages to be inserted into the text.

pages to be replaced	pages to be inserted (10/68)
1) 2.4(a), page 1/blank	2.4(a), page 1/page 2
2) 2.6(a), page 1/blank	2.6(a), page 1/page 2, page 3/page 4, page 5/page 6

PREFACE

Supplement 2 to the Preliminary Safety Analysis Report for Indian Point Nuclear Station No. 3 consists of responses to the AEC Questions on Containment Design requested in the letters of February 19, 1968 and July 16, 1968 to Consolidated Edison Company of New York.

Those questions from the July 16, 1968 letter which are included in Supplement 2 are directed mainly to the base mat construction and the reinforcing steel for the base concrete over the bottom liner plates. The remaining questions in the July 16, 1968 letter will be submitted to the AEC in a later supplement.

Those questions from the July 16, 1968 letter which are included in this supplement are as follows:

> 2.3, 2.4(a) [partial]-(b)-(e), 2.5(a)-(b)-(c), 2.6(a)-(b), 2.7(a)-(b)-(c)-(d)-(e)-(f), 2.8(k)-(l), 3.0 (all), 4.0 (all), 5.0 (all), 6.0 (all).

PREFACE TO SECTION 1

The following questions in this section were originally asked by the AEC reviewers for the Indian Point Nuclear Generating Unit No. 2 in the letters of February 28, 1966 and May 11, 1966 respectively. In the February 19, 1968 letter by the AEC, the following questions were raised for Unit No. 3. Since some of the questions refer to page numbers in the Unit No. 2 PSAR, the correct page number or section for Unit No. 3 has been cited in brackets where possible for clarity.

From the letter of February 28, 1966. The AEC has asked that the questions under the heading Containment Design Information be answered in the context of Unit No. 3. From the letter of May 11, 1966, the AEC has asked that Question 9 be answered for Unit No. 3.

February 28, 1966 - Containment Design Information

1. In load criteria on page 5-8 (Exh. B, Vol.2, Part A) - [page 5-9 (Exh. B, Vol. 2, Part A), Unit 3], what values of parameters correspond to the values of T, TL, T', TL'? What are the temperatures in the interior and at the steel locations?

ANSWER

The values of parameters corresponding to TL and TL' are 306°F and 285°F respectively. The pressure-temperature transient curves for these loading conditions are shown in Figures 5-3 and 5-4 of the PSAR. The maximum operating temperature is 120°F and the design 24 hour mean-low ambient temperature is -5°F. The temperature gradient through the wall is essentially linear on both the insulated and uninsulated portions and is a function of the operating temperature internally and the average ambient temperature externally. Accident temperatures mainly affect the liner, rather than the concrete and reinforcing bars, due to the insulating properties of the concrete. By the time the temperature of the concrete adjacent to the liner begins to rise significantly, the internal pressure and temperature in the containment shell due to maximum thermal gradient will not influence the capacity of the structure to resist the other forces.

February 28, 1966 - Containment Design Information

2. How is the lateral force (shear) in the structure carried? Is there shear reinforcement? For the liner, elastic stability provisions and load capacity based on yield are noted on page 5-9 [p. 5-12, Unit 3]. How does the steel liner participate in carrying the shear and other loads? What anchorage means is contemplated?

ANSWER

The seismic shear force will be resisted by diagonal shear reinforcing in the circumferential direction for the full height of the wall and a distance above the spring line into the dome until a point is reached where the dome liner can resist the total shear. The required capacity of the diagonal bars will be determined such that the horizontal component per foot of the diagonals will be equal to the maximum value of shear flow. For all of the cylinder and the lower areas of the dome, the diagonal reinforcing will be designed to accommodate all seismic shears. No credit will be taken for the dowel action of the vertical and horizontal bars in resisting seismic shear.

Although the liner has some capacity available to resist the seismic shears, no credit will be taken for this capacity in the design of the cylinder. Only in the upper area of the dome (beyond about 30° above the spring line) where the seismic shears are small will the liner be counted on to resist shear.

The liner will be anchored to the concrete shell by means of L shaped nelson studs so that it forms an integral part of the entire composite structure under all loadings.

February 28, 1966 - Containment Design Information

3. How will the splicing of the large 14S and 18S bars be handled? A general sketch of the contemplated reinforcing bar patterns is desirable.

ANSWER

Reinforcing bars No. 14S and 18S will be spliced by the Cadweld process. The splices used to join reinforcing bars will be tested to assure that they will develop at least 125% of the minimum yield point stress of the bar. The test program will require cutting out, at random, completed splices and testing to determine their breaking strength. The capacity of splices will be in accordance with ACI 318-63. A general sketch of the contemplated reinforcing bar patterns in the base mat and juncture with the wall is shown in Figure 2.4(a) - 3 of Supplement 2.

Feb. 28, 1966 - Containment Design Information

4. What special provisions or special studies will be made to insure the adequacy of the penetrations (large and small) in terms of retaining strength and ductility while preventing leakage. Details of the concept of reinforcement around penetrations are desirable.

ANSWER

The liner is basically not a load carrying member because it is subjected to strains imposed by the reinforced concrete; nevertheless, the liner will be reinforced at each penetration in accordance with the ASME Code Section VIII. The weldments of liner to penetration sleeve will be of sufficient strength to accommodate stress concentrations and will adhere strictly to ASME Code Section VIII requirements for both type and strength. The penetration sleeves and plates are designed to accommodate all loads imposed on them under operating conditions (thermal effects and internal penetrations and test pressures) and accident conditions (loads resulting from all strains, internal pressures, and seismic movements). The sleeves are designed to remain within ASME Code Section VIII stress limitations. Liner reinforcement will be designed to support penetrations in the appropriate portion of liner plate during shop testing, shipping and field erection.

In the cylindrical section of the containment, where there are large openings for access hatchways and penetrations, the reinforcing bars (hoop, diagonal and vertical) will be continued without interruption around the openings. No bar will terminate at any opening. Also additional bars will be furnished locally to take the stresses developed around these openings. Concrete will be locally thickened at the equipment access hatchway area to accommodate all the reinforcing bars required in this area.

Feb. 28, 1966 - Containment Design Information

5. A tabulation of sources of stress, along with the appropriate allowable stress (or permissible resisting load and load factor) values, would help clarify the design approach. Also, a discussion of allowable ductility and provisions for obtaining same, is desirable.

ANSWER

The loads utilized to determine the required limiting capacity of any structural element on the containment structure are given in Section 5.1.2.4 of the PSAR. All structural components will be designed to have a capacity required by the most severe loading combination. The load factors utilized in these equations are based upon the load factor concept employed in ACI-318-63, Part IV-B, "Structural Analysis and Proportioning of Members Ultimate Strength Design".

No steel reinforcement will experience average strains beyond the yield point at the factored load. The load capacity so determined will be reduced by a capacity reduction factor "Ø" which will provide for the possibility that small adverse variations in material strengths, workmanship, dimensions, and control, while individually within required tolerances and the limits of good practice occasionally may combine to result in under capacity. For tension members, the factor "Ø" will be established as 0.95. The factor "Ø" will be 0.90 for flexure and 0.85 for diagonal tension, bond and anchorage. For the liner steel the factor "Ø" will be 0.95 for tension. For compression and shear, the liner stress will be maintained below 0.95 yield and elastic stability will be assumed.

Feb. 28, 1966 - Containment Design Information

6. What magnitude of vertical acceleration in earthquakes will be considered?

ANSWER

The magnitude of vertical acceleration in earthquakes will be 0.05g for the design earthquake and 0.10g for the hypothetical earthquake.

Feb. 28, 1966 - Containment Design Information

7. In citation (ii) it is noted that "...any vertical acceleration would be counteracted by the weight of the building". This statement is not correct. Also, vertical seismic motion should be assumed to act simultaneously with horizontal excitation. A more scientifically valid criterion for the earthquake analysis is required.

ANSWER

The earthquake to be used for the design (design earthquake) of this plant is a ground acceleration of 0.10g horizontally and 0.05g vertically, acting simultaneously. In addition, the design is for no loss of function for an earthquake (hypothetical earthquake) with a ground acceleration of 0.15g horizontally and 0.10g vertically acting simultaneously.

Feb. 28, 1966 - Containment Design Information

8. In the table of damping values given on p. 5-16 [p. 5-23, Unit 3], the damping factors for the containment structure is shown as 7.0 per cent of critical and for the concrete support structure, item 2, 5 percent. Similar values are shown in item 5. On what basis were these selected? Such large values correspond to rather heavily cracked concrete sections, stressed well into the yielding range. Lower values would be much more reasonable.

ANSWER

The damping factors to be used for the design of concrete structures are found in the response to questions 2.7 (c) and (d) of Supplement 2 to the PSAR.

February 28, 1966 - Containment Design Information

9. A description of the actual analysis techniques that will be employed in arriving at the design would be helpful. Only indirect statements about the procedures to be followed are given in the report on page 5-16 [p. 5-22, Unit 3]. What rigorous and acceptable procedures will be followed? How will the response spectra be employed in the procedures?

ANSWER

The design of the containment will utilize the "response spectrum" approach in the analysis of the dynamic loads imparted by earthquake. The seismic design will be based on the acceleration response spectrum curves presented in TID 7024. The natural period of vibration is computed as shown in answer to 2.7 (a) of Supplement 2. The containment structure is analyzed as a simple cantilever intimately associated with the rock base and with broad base sections of adequate strength to assure full and continued elastic response during seismic motions. Further, both bending and shear deformations are considered.

February 28, 1966 - Containment Design Information

10. What criteria exist for adding the stresses arising from the different loadings, in contrast to combining loads? Since the loads act in different directions in many cases, a stress (or load resistance) combination approach would appear to be more rational. Discussion and comment is needed.

ANSWER

Refer to page 5-9, Section 5.1.2.4 of the PSAR and to page 5-17, Section 5.1.3 of the PSAR for the criteria for combining stresses.

February 28, 1966 - Containment Design Information

11. What wind loads will be assumed in the design?

ANSWER

Refer to page 5-6 of the PSAR.

May 11, 1966

9. Please provide the following containment design information:

   a. In Table 5-4, page 5 of the First Supplement; Damping Factors: The damping for item (1) the containment structure, item (2) concrete support structure of reactor vessel, and item (5) concrete structure above ground including shear walls and rigid frames, are all shown as 5.0 per cent of critical damping. It is our belief from available data that such high values can only be assured of existing in severely cracked concrete sections. A much more reasonable value would appear to be about 2.0 per cent, a value which we would prefer be employed for items (1) and (2). We would not object to the use of 5.0 per cent for item (5). Your comments on these considerations are invited.

ANSWER

Refer to response to Question 2.7(d) of Supplement 2 to the PSAR.

May 11, 1966

9. Please provide the following containment design information:

   b. Although reference is made to the spectra to be employed, we find no plot or other adequate identification of the design spectra. We request that a plot of the spectra to be employed in the design be made available so that there is no question as to the magnitudes of the design forces.

ANSWER

Refer to Figures 5-7 and 5-8 of the PSAR.

May 11, 1966

9. Please provide the following containment design information:

c. With regard to Question 7 in the First Supplement, we can find no statement indicating that in computing design forces the vertical seismic motion will be assumed to act simultaneously with the horizontal excitation. It is obvious from recordings of earthquake motions that excitation does occur in all directions simultaneously, and the design must reflect such loading conditions. A statement clarifying the intentions in this respect is requested.

ANSWER

Refer to page 5-11 of the PSAR.

May 11, 1966

9. Please provide the following containment design information:

   d. No statements are made in the PSAR or in the First Supplement regarding safe shutdown provisions under seismic loading. What is the design criterion in this regard?

ANSWER

Refer to Section 5.1.2.4 of the PSAR.

May 11, 1966

9. Please provide the following containment design information:

   e. It is still not clear from Question 2 in the First Supplement and the discussion as to exactly what extent the containment liner participates in carrying loads. If it is fastened firmly to the concete shell with Nelson studs, the liner will necessarily participate in terms of transmitting loads or alternatively providing resistance. More importantly perhaps is the question of use of Nelson studs with this material. What studies will be made or have been made to indicate that the zone of fastening between the stud and plate will remain uncracked and leak tight? There have been reported cases of fatigue cracking and strength difficulties of studs in cases where cyclic loading (even only a few cycles) occurred. Will any special welding techniques, inspection, tests, or research be employed to help lend confidence to this design? In our opinion, special studies relating to these problems are desirable, and we would appreciate your comments in this regard.

ANSWER

Refer to page 5-13 of the PSAR.

QUESTION 2.3

If the containment structure base is located below ground water level, describe the waterproofing or other protection to be used between the soil and the containment. Evaluate the possibility and consequences of base mat cracking and of ground water reaching the liner and the reinforcing. Include the effect on liner stability and liner and reinforcing corrosion.

ANSWER

The containment structure base is located above ground water level. The mean high water level is El. + 2.2'. The maximum high water level is El. + 7'-6". The evaluation of the bottom of the containment structure base at the lowest point is El. + 13'-0", thus a difference of 5' -6" exists between bottom of containment and maximum high water and no ground water problems are anticipated.

QUESTION 2.4

For the containment structure, provide:

(a) A preliminary design drawing of the containment presenting details of the base slab, dome-cylinder junction, cylinder-slab junction, showing reinforcing and liner features, including liner anchors.

ANSWER

The preliminary design drawings are given in Figures 2.4(a)-1 through 2.4(a)-4. The preliminary design drawings for the dome-cylinder junction will be given in a subsequent supplement to the PSAR.

The shear reinforcing is placed in the mat to accomodate redistribution of internal forces should a diagonal crack occur. The density of the reinforcing steel in the mat is including the wall dowels in 11 lb/cu. ft.

The shear stresses in the inclined stirrups in the mat are calculated for the 1.25P loading condition which is the most severe loading condition for shear considerations due to the uplift from the design earthquake with only 2% critical damping. Formula (17.5) of the ACI 318-63 Code is used to calculate the shear stresses. The anchorage bond stresses in the bars are calculated and compared with the allowable bond stress of $.8 \times .6\sqrt{f'_c} = 262$ psi recommended in Chapter 18 of the ACI-318 Code. In no case is the allowable bond stress exceeded. The following is a table of the shear and anchorage bond stresses for the stirrups:

Stirrups	Shear Stress	Bond Stress
#18S	$45^k/in^2$	240 psi *
#14S	$20.1^k/in^2$	87 psi **
#11	All shear can be taken by the concrete section	

* The anchored portion of the stirrup is in a compression zone, therefore, the problem of anchorage is greatly reduced.

** In the event that a crack opens and reduces the anchorage length, it can be seen that a margin of safety of approximately 3 exists between the actual stress and the allowable stress.

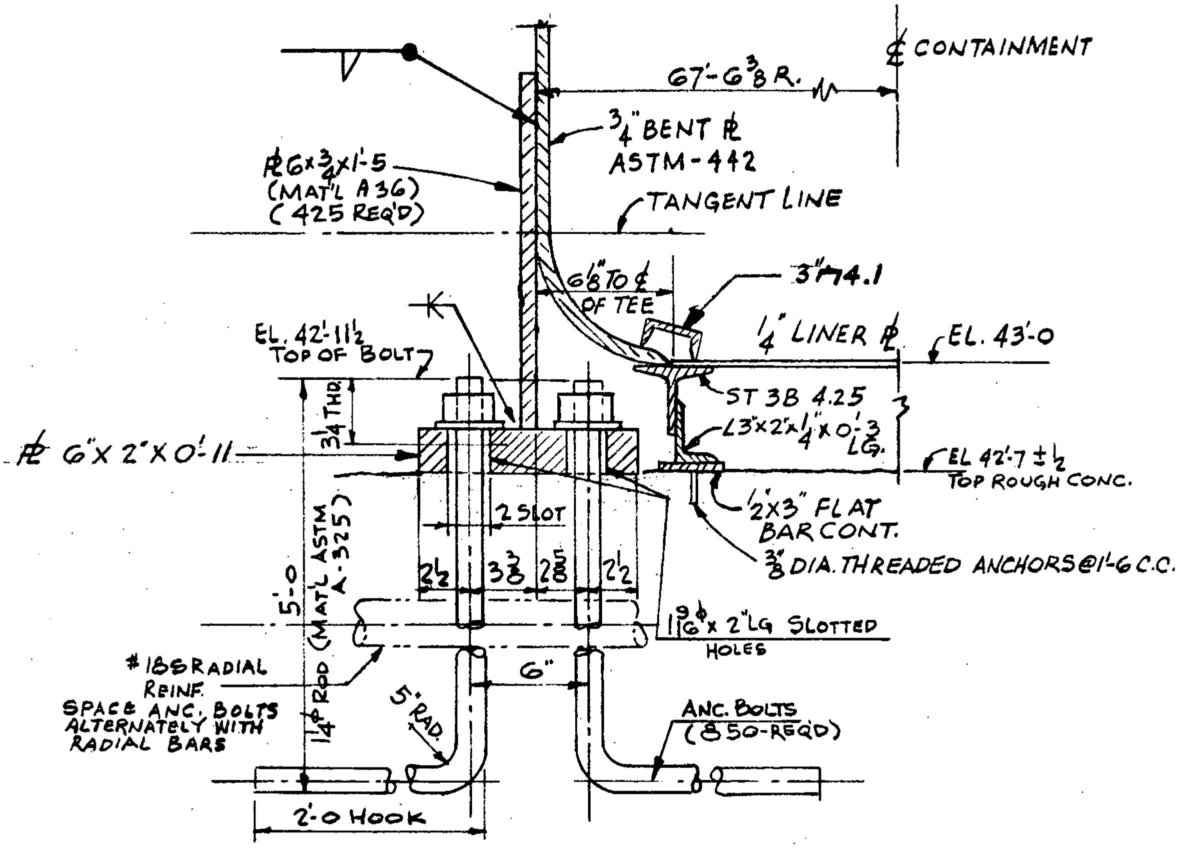
The length of the stirrup above or below mid-height of the mat is used as the anchorage length.[1] No credit is taken for the additional anchorage provided by the bend in the bar. It is felt that this assumption is conservative since standard hooks in tension may be considered to develop 10,000 psi working stress, or 19,000 psi ultimate stress in the bar, or may be considered as simple extensions of the bars at the appropriate bond stresses.[2]

The diagonal shear reinforcing will terminate at approximately 20'-0" above the base. At this point the radial shear from the discontinuity at the base mat cylinder junction has virtually dissipated and the steel has been carried past the point of requirement specified in the ACI-318 Code.

There are two types of radial shear reinforcing; the inclined stirrups and the secondary vertical bars which are bent across the wall. The inclined stirrups are mechanically anchored by hooking them around the vertical bars. Each secondary vertical bar is terminated further up the wall by splicing it to a #11 bar and mechanically anchoring this bar with a 180° hook.

1. "Reinforced Concrete Fundamentals" by Phil. M Ferguson - John Wiley & Sons, 1958.

2. "Design of Concrete Structures" by George Winter, L. C. Urquhart, C. E. O'Rourke, and Arthur H. Nilson - McGraw-Hill Book Company - 1964.



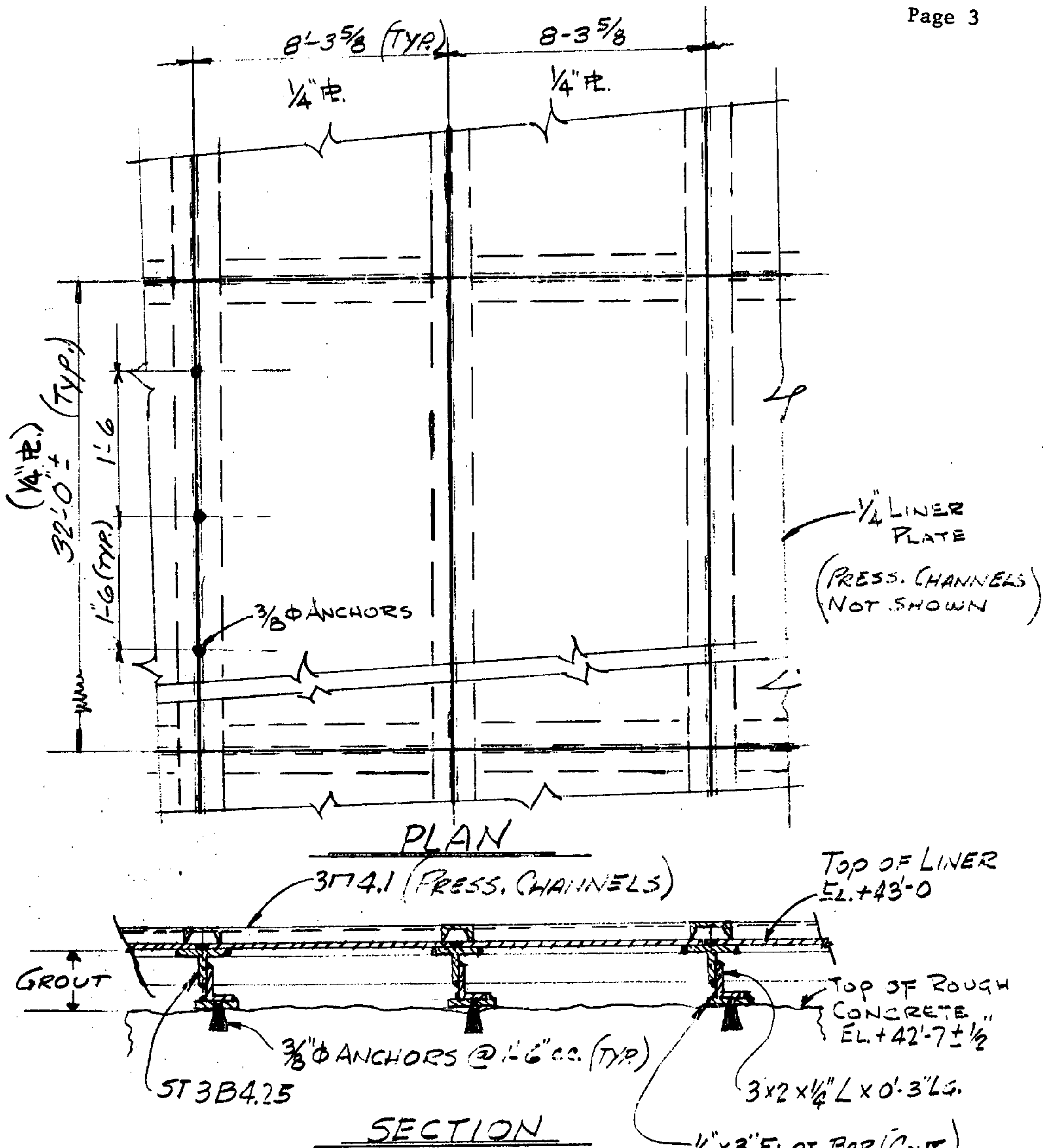
CYLINDER - BASE SLAB LINER JUNCTURE

1 1/2" = 1'-0

Figure 2.4(a)-1

Supplement 2

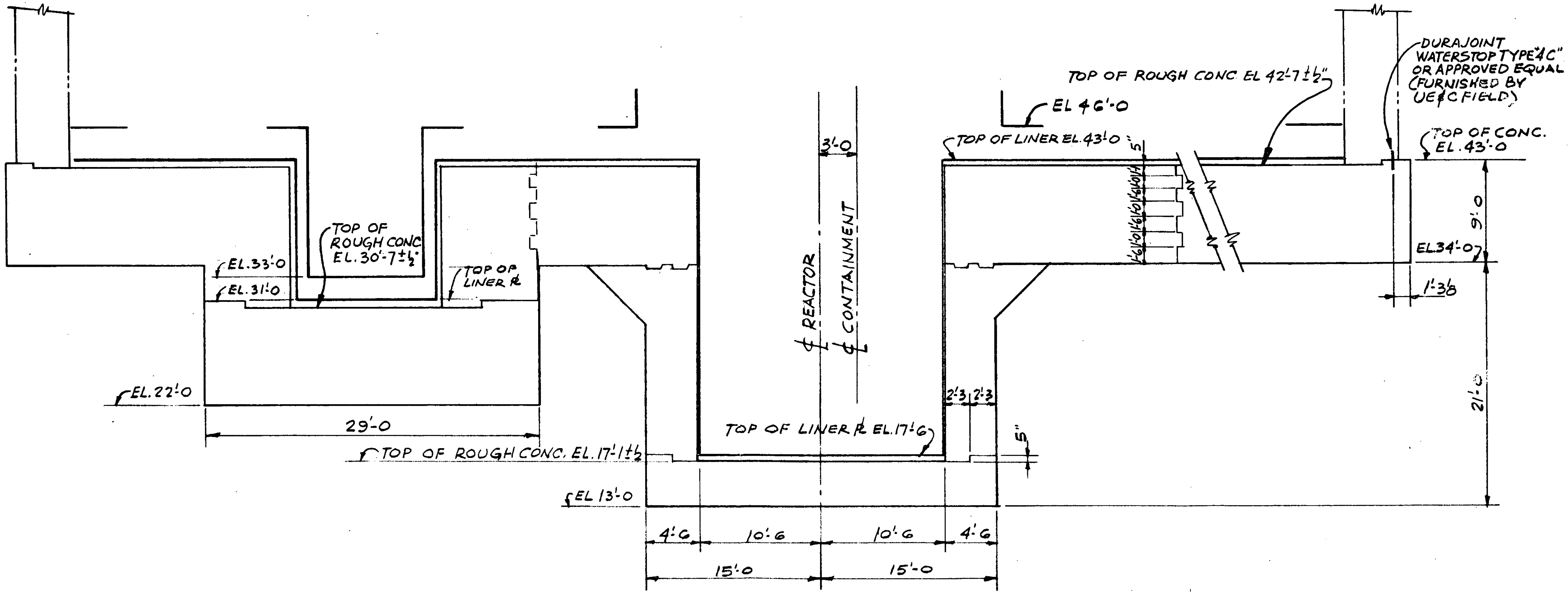
R 36775-2 Paden



TYPICAL BASE MAT LINER DETAIL

Figure 2.4(a)-2
Supplement 2

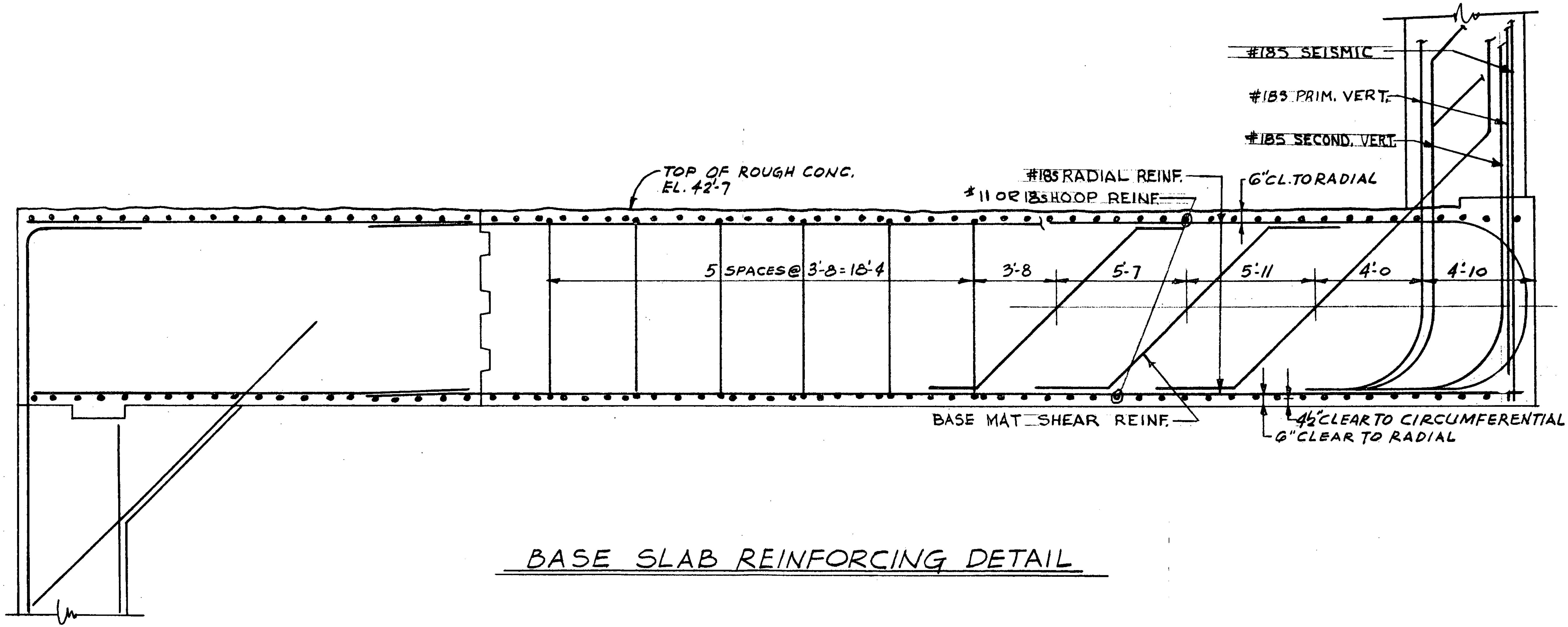
R 36775-2 Paden



CONTAINMENT BLDG. SECTION THROUGH EAST-WEST ℄
1/8" = 1'-0

Figure 2.4(a)-4
Supplement 2

R 36775-1



BASE SLAB REINFORCING DETAIL

Figure 2.4(a)-3
Supplement 2

R 36775-2 Paden

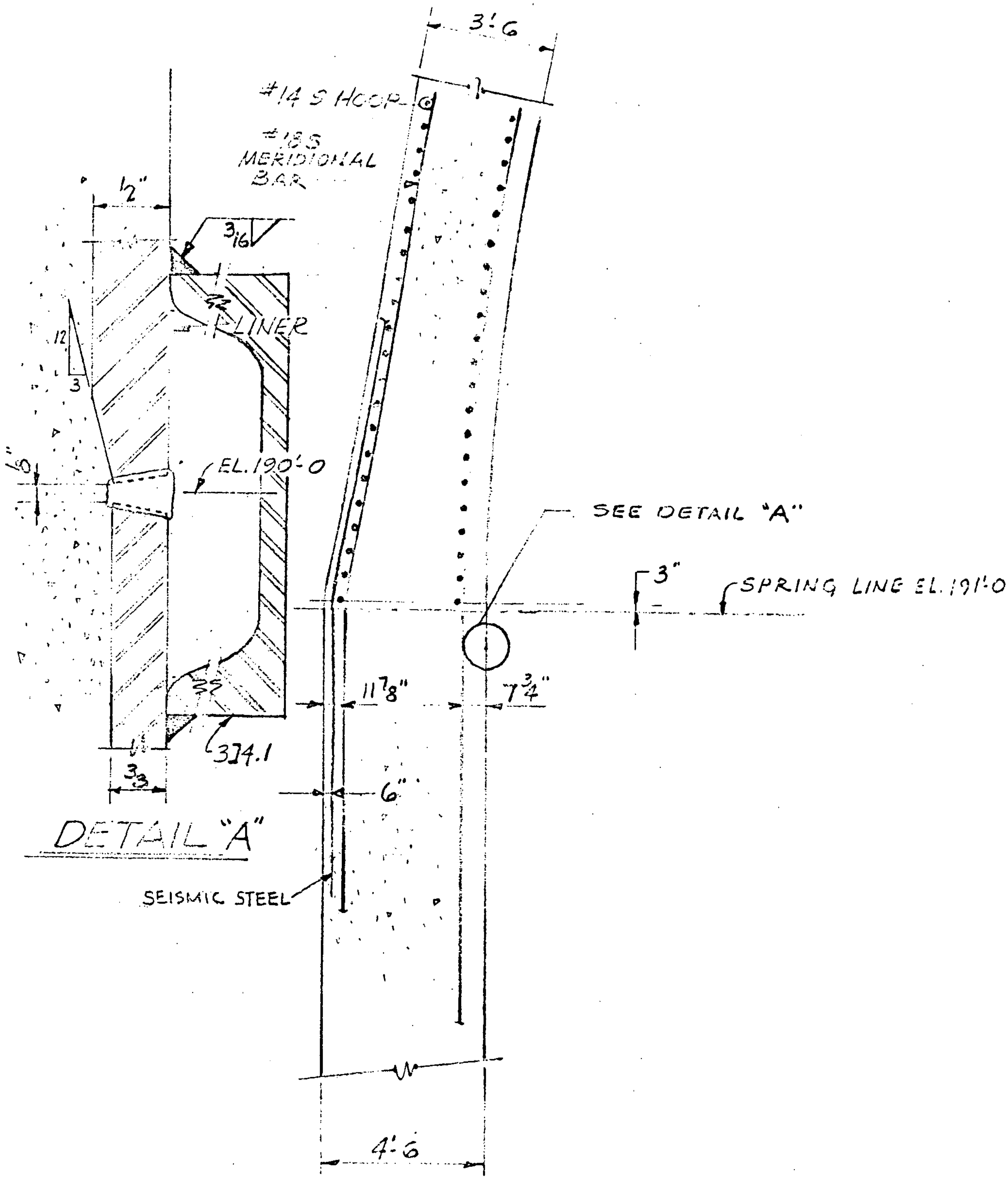


FIGURE 2.4(a)-1
Supplement 4

QUESTION 2.4

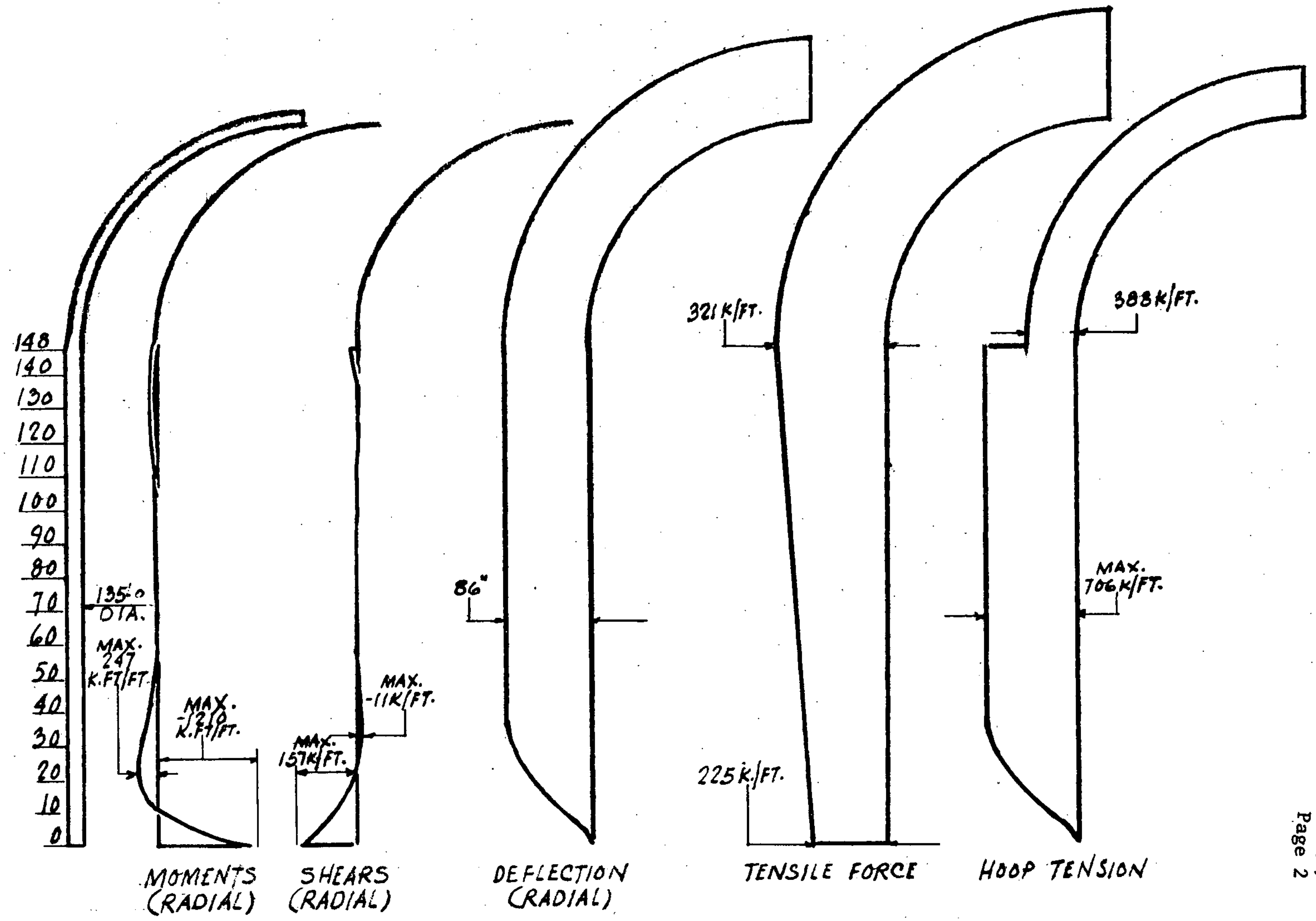
For the containment structure, provide:

(b) Scaled load plots for moment, shear, deflection, longitudinal force, and hoop tension, in order that an appraisal can be made of the significance of the various loadings which influence the containment design. Provide these plots for several containment heights for the following loadings: dead, pressure, operating basis earthquake (smaller earthquake), wind, liner thermal (normal and accident) and concrete thermal (normal and accident).

ANSWER

The design loads resulting from the factored load equations presented in Section 5.1.2.4 of the PSAR are shown in Figures 2.4(b)-1 through 2.4(b)-3. Individual load plots are shown in Figures 2.4(b)-4 through 2.4(b)-8.

$$C = 1.0D \pm 0.05D + 1.5P + 1.0(T + TL)$$



R36775-2 Paden

Figure 2.4(b)-1
Supplement 2

R 36775-2 Paden

$$C = 1.0D \pm 0.05D + 1.25P + 1.0(T' + TL') + 1.25E$$

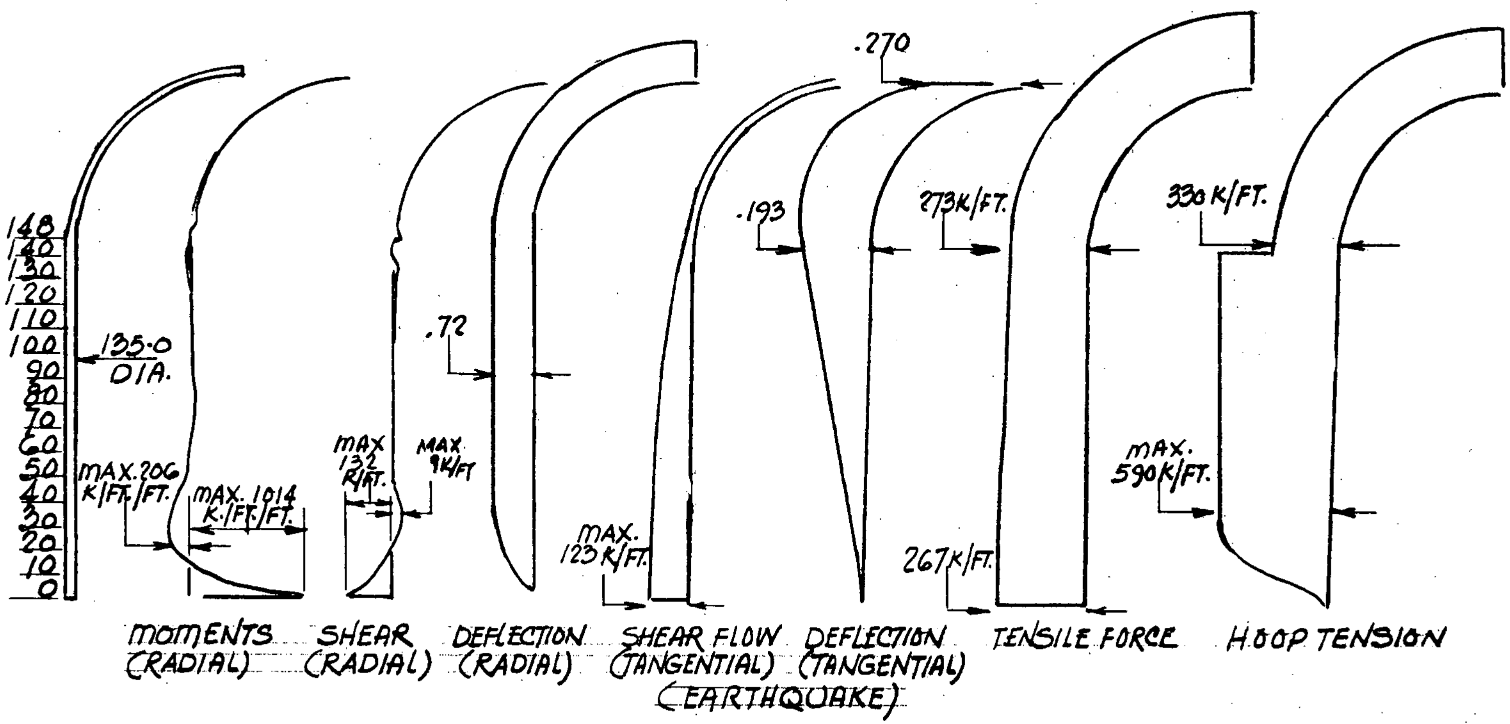
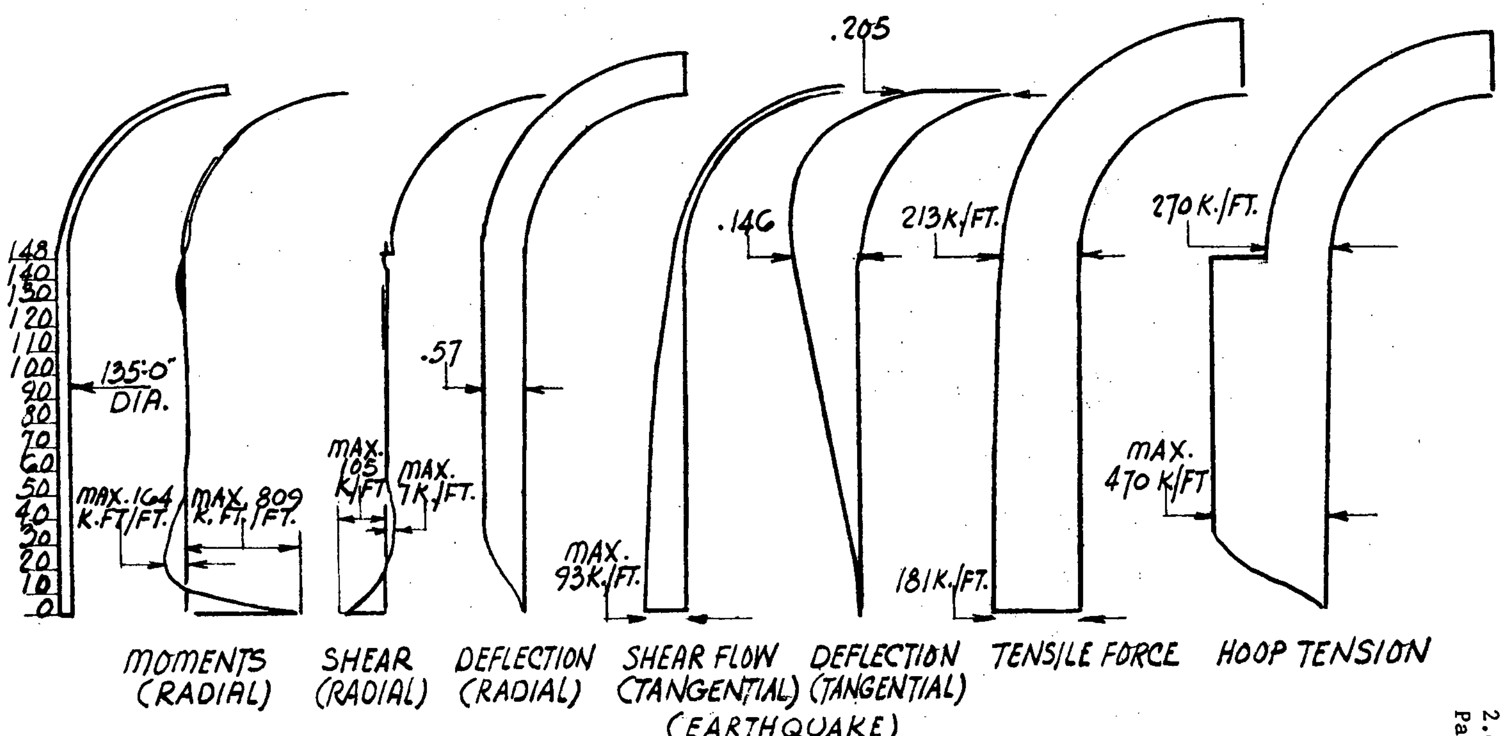


Figure 2.4(b)-2
Supplement 2

$$C = 1.0D \pm 0.05D + 1.0P + 1.0(T'' + TL'') + 1.0E'$$



R 36775-2 Paden

Figure 2.4(b)-3
Supplement 2

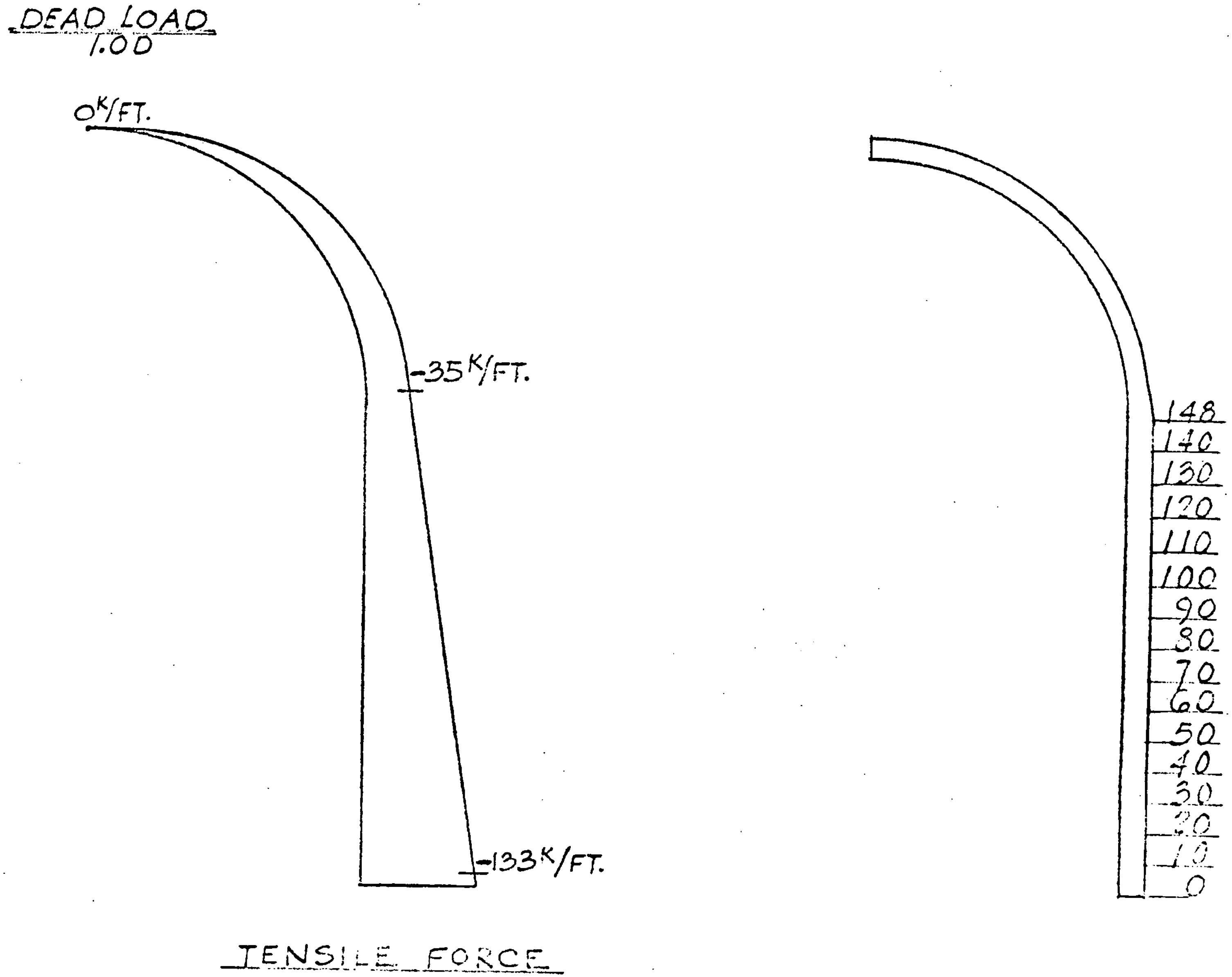
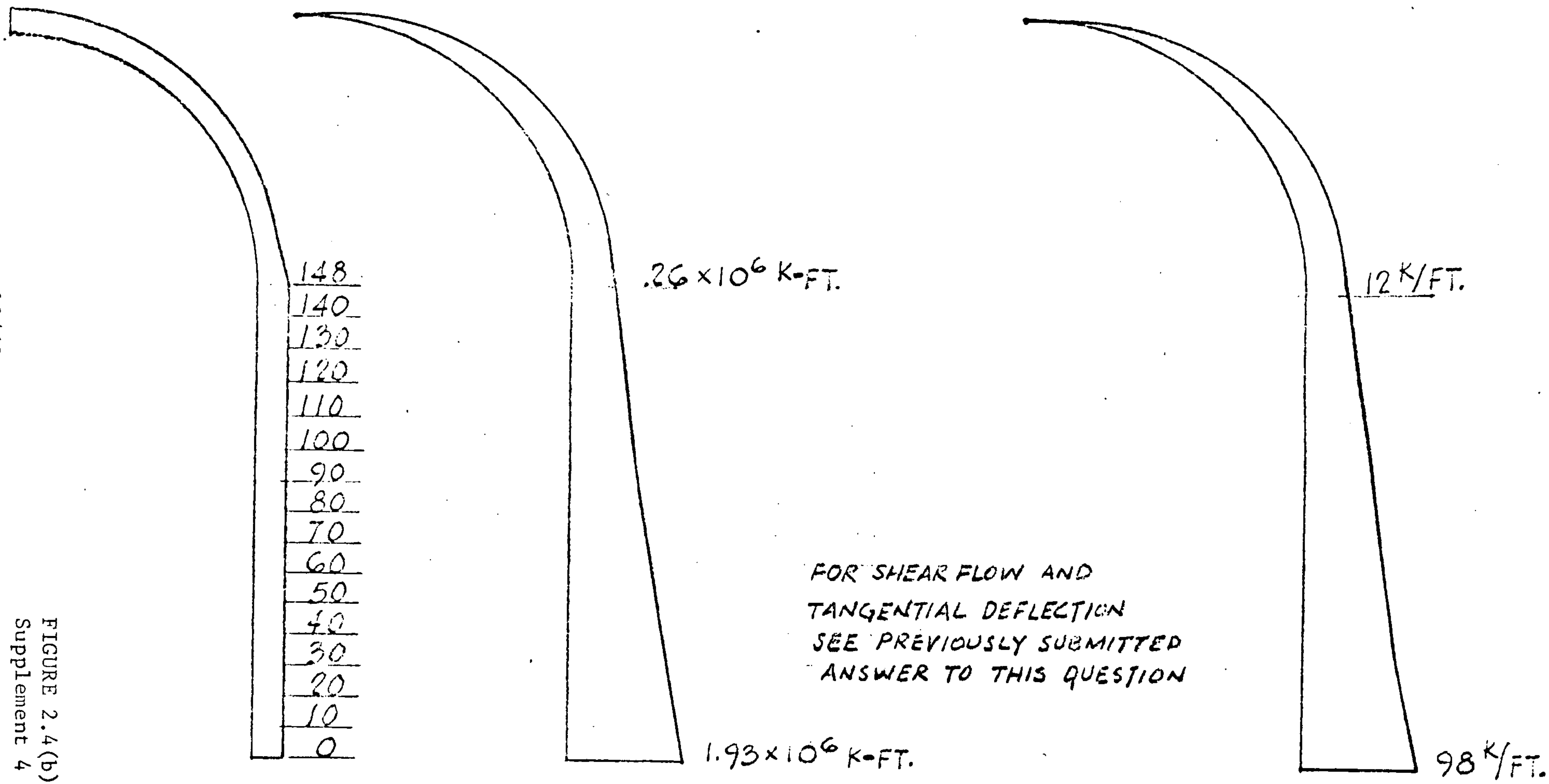


FIGURE 2.4(b)-4
Supplement 4

$$C = 1.0D \pm 0.05D + 1.25P + 1.0(T' + TL') + 1.25E$$

SMALL EARTHQUAKE



UPLIFT MOMENTS

TENSILE FORCE

FIGURE 2.4(b)-6
Supplement 4

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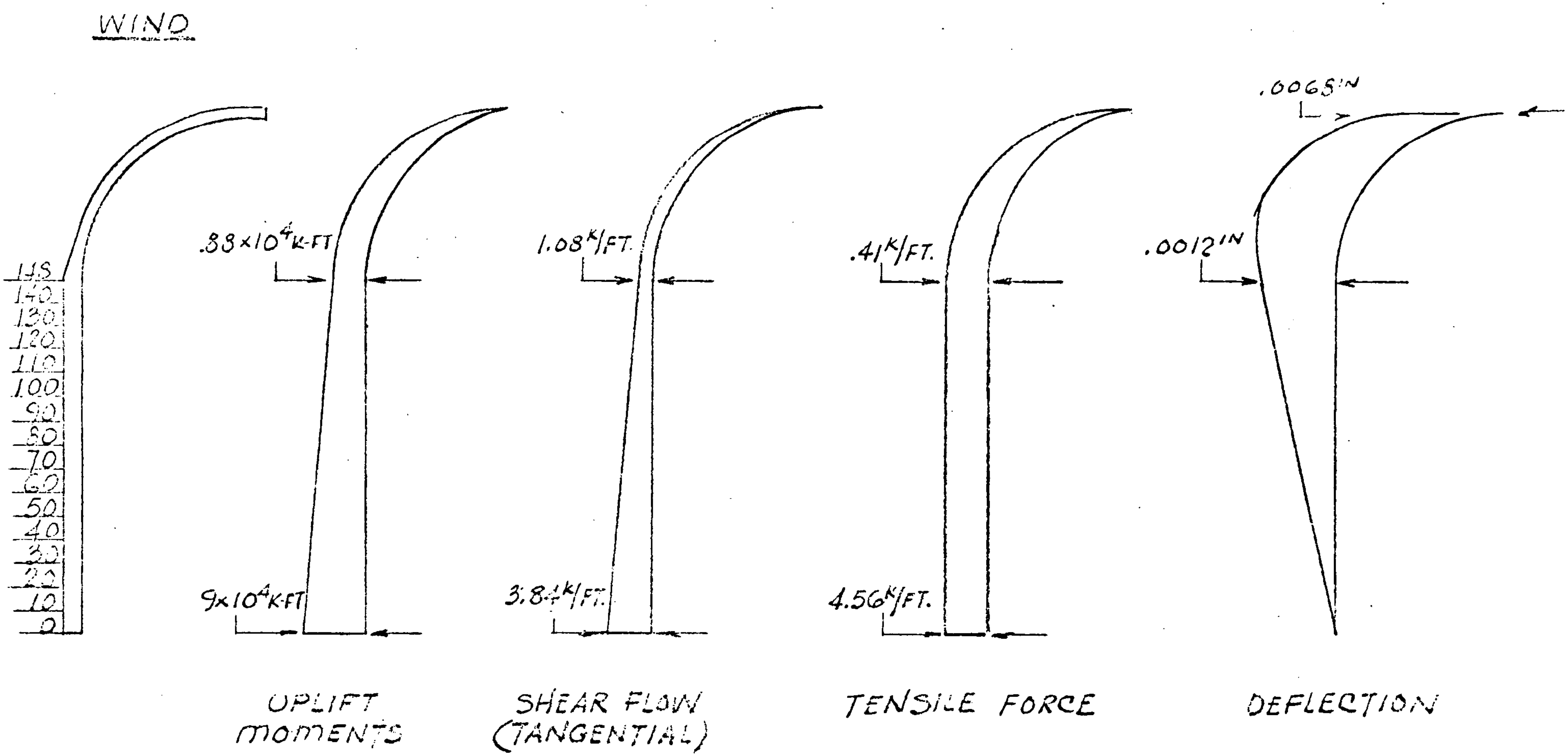

FIGURE 2.4(b)-7
Supplement 4

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$$C = 1.0D \pm 0.5D + 1.0P + 1.0(T'' + TL'') + 1.0E'$$

$$C = 1.0D \pm 0.05D + 1.25P + 1.0(T' + TL') + 1.25E$$

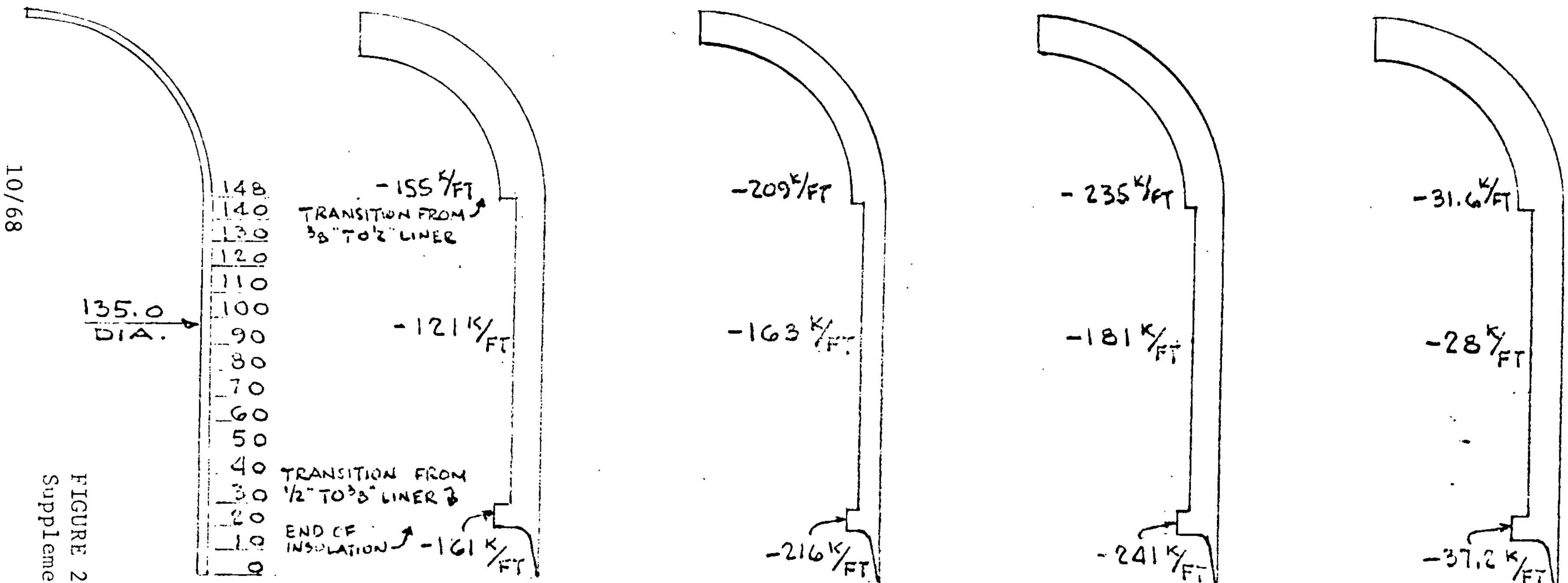
$$C = 1.0D \pm 0.05D + 1.5P + 1.0(T + TL)$$

NOTE: ALL CONCRETE THERMAL FORCES ARE EQUAL TO AND OPPOSITE IN SIGN FROM THE LINER THERMAL FORCES

THERMAL (ACCIDENT)

THERMAL (NORMAL WINTER)

1.0P | 1.25 P | 1.5 P | FOR ALL LOADING CONDITIONS



LONGITUDINAL & CIRCUMFERENTIAL FORCE | LONGITUDINAL & CIRCUMFERENTIAL FORCE | LONGITUDINAL & CIRCUMFERENTIAL FORCE | LONGITUDINAL & CIRCUMFERENTIAL FORCE

FIGURE 2.4(b)-8
Supplement 4

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$$C = 1.0D \pm 0.05D + 1.0P + 1.0(T'' + TL'') + 1.0E'$$
$$C = 1.0D \pm 0.05D + 1.25P + 1.0(T' + TL') + 1.25E$$
$$C = 1.0D \pm 0.05D + 1.5P + 1.0(T + TL)$$

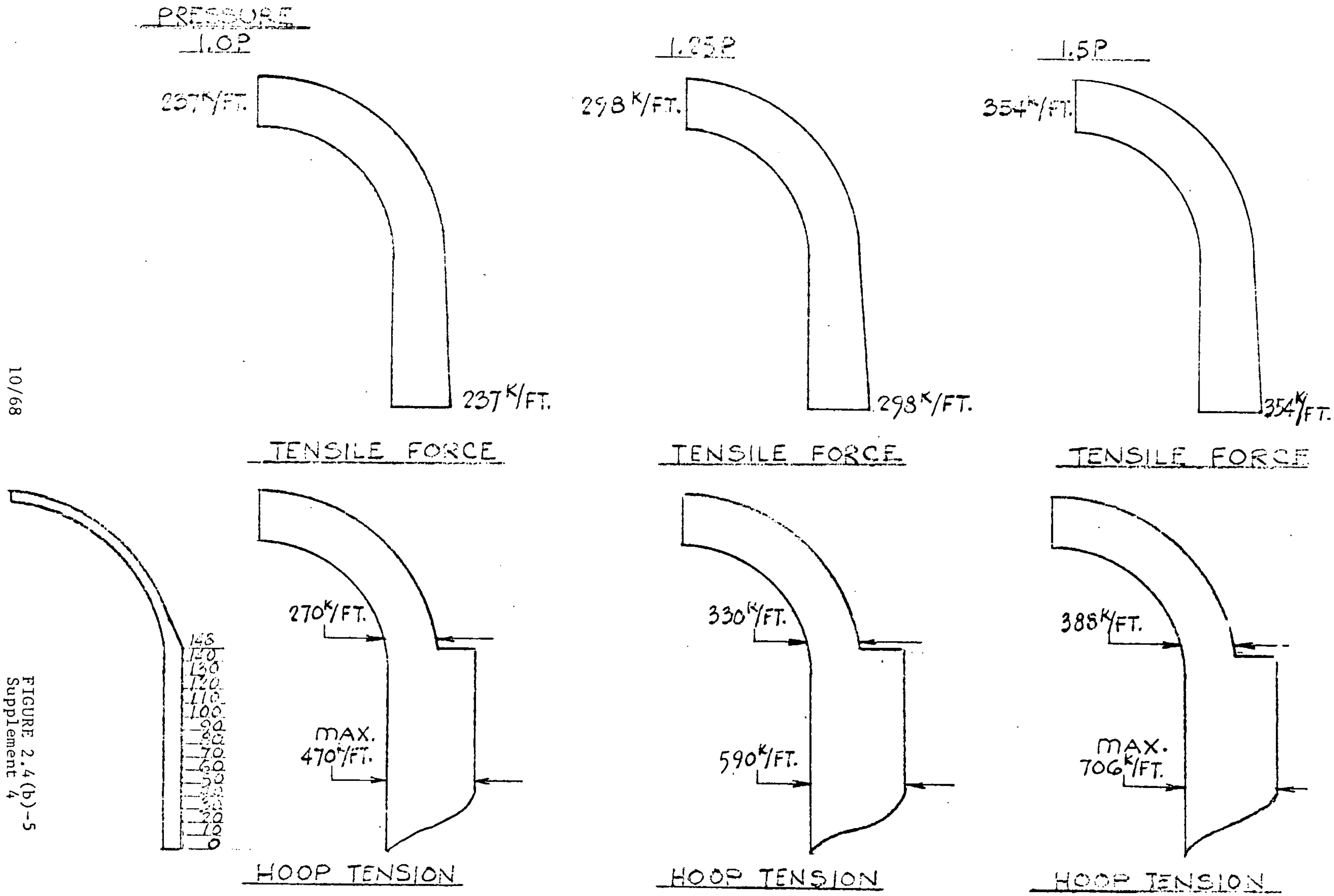

FIGURE 2.4(b)-5
Supplement 4

10/68

QUESTION 2.4(e)

For the containment structure, provide:

(e) The analytical procedures used for arriving at the forces, shears, and moments in the structural shell, and the analytical procedures used for determining discontinuity stresses at the base and dome. State the assumptions, with regard to structural stiffness, that from the basis for these stress determinations and indicate the extent to which variations of E_c and u_c are considered.

ANSWER

The differential equation (Theory of Plates and Shells, Timoshenko Woinowsky-Krieger, 1959, Pg. 468).

$$\frac{D\, d^4 w}{dx^4} + \frac{E_s h_s}{a^2} w = Z$$

represents the basis of solution for all problems of symmetrical deformation of circular cylindrical shells of constant wall thickness. The solution of this **differential** equation is,

$$w = \frac{e^{-Bx}}{2B^3 D} \quad BM_o \;(\sin Bx - \cos Bx) - \;(Q_o \cos Bx) + \frac{a^2 Z}{E_s h_s}$$

For the fixed end condition,

$$(w)_{(x = o)} = \frac{-1}{2B^3 D} \;(B\, M_o + Q_o) + \frac{a^2 Z}{E_s h_s} = 0$$

and

$$\left(\frac{dw}{dx}\right)_{(x = o)} = \frac{1}{2B^2 D} \;(2BM_o + Q_o) = 0.$$

The nomenclature for the above equations referred to Figure III-2.4.4.1-A and are defined as follows:

D is the flexural rigidity

w is the radial deflection of the wall

x is the distance from the intersection of the wall and base

E_s is the modulus of elasticity

a is the mean radius of the wall

h_s is the area of circumferential membrane steel and liner per unit height of cylinder.

Z is the load intensity

$$B = 4 \sqrt{\frac{E_s h_s}{4 a^2 D}}$$

M_o is the moment at the base

Q_o is the shear at the base

The moment and shear distribution at the base and above are evaluated from the preceding equations. This, in turn, permits an analysis of the structural sections and dictates the need for reinforcements in the concrete.

A study was made varying Ec. $\pm$ 20% from the value of 3.2×10^6 psi and u_c from 0 to .3. For the worst combinations, the values of discontinuity moment and shear vary by 14 and 7 percent respectively from the design values.

In analyzing the dome and cylindrical portion of the containment structure the following basic assumptions are made:

All membrane tensile stresses are assumed to be carried by the concrete reinforcement and none by the concrete. This statement reiterates a basic ground rule; namely, that the conrete will not be counted upon to resist stresses other than compression, bond and shear. There is also further need for diagonal shear reinforcing in the circumferential direction over the full height of the wall to resist earthquake shears. This diagonal shear reinforcing is also used to accommodate the loads resulting from the 115% over pressure test.

Internal pressures acting on the thin walled pressure vessel cause circumferential and meridional tensile membrane stresses in the dome and cylinder.

Dead load results in compressive meridional stresses in the cylinder and compressive and tensile circumferential membrane forces in the dome. The cylinder walls will be in compression vertically, with no circumferential forces except for small forces at the spring line.

The earthquake horizontal component and wind will result in circumferential shear forces with the maximum force/foot parallel to the direction of motion. The overturning moment due to earthquake or wind forces will cause vertical forces in the wall and the maximum tensile and compressive forces 180° apart in the direction of motion. The vertical earthquake results in compressive and tensile meridional stresses.

The analysis of the cylinder is accomplished by the superposition of membrane forces resulting from gravity, pressure and thermal loads; overturning due to earthquake; and shears due to earthquake. Diagonal bars are placed to resist the horizontal and vertical shears due to earthquake or wind. The required capacity of the diagonal bars is determined such that the horizontal component per foot of the diagonals is equal to the maximum value of shear load and internal pressure load. Although in the cylinder the liner has some capacity available to resist the seismic shears in the cylinder, no credit is taken for the capacity. For all of the cylinder and the lower areas of the dome, the diagonal reinforcing is designed to accommodate all seismic shears. No credit is taken for diagonal bars in compression. No credit is taken for the dowel action of the vertical and horizontal bars in resisting seismic shear.

For a discussion of thermal load effects, see the answer to question 2.4(i).

Discontinuity forces at the dome-cylinder junction are a function of the relative deformation at this point, since the deflections of the dome and cylinder must be equal. There is less rebar in the dome than in the cylinder so that the stresses are about the same and discontinuity effects will be insignificant.

The analysis of the hemispherical dome is performed by the superposition of membrane forces resulting from gravity, accident pressure and accident thermal loads. In addition, earthquake loading create both direct and shear stresses in the dome and the operating temperature of the liner creates tension and compression. In the upper area of the dome (beyond about 30° above the spring line) where the seismic shears are small, seismic shears are carried by the dome liner plate.

QUESTION 2.5

Indicate whether the following have been or will be considered:

(a) The cracking of the cylindrical wall, compared with the behavior of the uncracked mat.

ANSWER

The containment analysis does take into account cracking of the cylindrical wall compared with an uncracked mat.

The discontinuity moments and shears are determined based on the mat being rigid. This assumption results in conservatively high moments and shears.

A parametric study has also bee made varying the degree of cracking in both the mat and the wall. This study revealed that while the calculated moments are sensitive to the degree of cracking, reinforcing stresses and concrete stresses remain consistent in value when these stresses are determined from the stiffness values assumed to develop the discontinuity effects.

QUESTION 2.5

Indicate whether the following have been or will be considered:

(b) The fact that the mat is under radial tension and is supported on a rigid foundation, restraining certain deformations of the mat.

ANSWER

In the outer portions of the base mat, the slab is raised off of the rigid foundation under accident loadings; thus no frictional resistance can be offered by the rigid foundation. Where the uplift is overcome, the only load of any consequence which must be resisted by the mat is the radial tension. The restraint which is imposed by the rigid foundation on the bottom portion of the base mat, effectively eliminates all radial tension in the mat. However, for conservatism this restraint has been neglected in analysis of the mat for radial tension. The hoop and radial reinforcing supplied as temperature reinforcing is more than adequate for this purpose.

QUESTION 2.5

Indicate whether the following have been or will be considered:

(c) The fact that the adjacent ground restrains the deformation of the wall.

ANSWER

To facilitate construction, a retaining wall will be built around the containment; the annulus between the containment and the retaining wall will be filled with a loose crushed stone. Calculations show that the earth pressures resulting from the crushed stone fill have a negligible effect on restraining the deformation of the wall.

QUESTION 2.6

For the base slab, describe:

(a) The analytical procedures used to arrive at the forces, moments, and shears, considering the rigid support afforded by the ground. State whether transient thermal gradients have been considered.

ANSWER

The base slab was treated as a flat circular plate supported on a rigid non-yielding foundation. For loads applied uniformly around the slab, the analysis considers a 1 ft. wide beam fixed at a point where the vertical shear is equal to zero. This is the point where the downward pressure on the mat and the dead weight overcome the uplift, at the containment wall base mat juncture, from pressure and earthquake loadings. Radial and circumferential reinforcing is provided at the top and bottom of the mat to resist moments in the areas where uplift occurs. Temperature steel was added in other areas to meet requirements of the (AC1-318) Code. Diagonal tension reinforcement was added to meet requirements of AC1-318 Code.

Moments and shears were calculated by writing equations for moment and shear in terms of X using the containment wall--base slab juncture as the origin with X increasing as you proceed toward the center of the containment building. The point along the circumference of the containment wall chosen as the end of the beam is a point where the maximum tension from the earthquake will exist. Since the containment structure is considered a beam in all earthquake analysis, the maximum uplift for which the mat is designed will occur at only one point on the circumference and will represent the worst possible uplift on the mat.

All stresses were calculated using Part IV-B Structural Analysis and Proportioning of Members - Ultimate Strength Design of the Building Codes Requirements for Reinforced Concrete (AC1-318-63). No rebar stresses exceed $.90\ f_y$.

A gradient with an operating temperature of 120°F inside the containment and a 50°F temperature at the mat-rock interface was considered and stresses are negligible. Accident temperatures have no appreciable effect on the base slab.

It is not possible to show the design on non-yielding rock is more conservative than assuming the rock to be elastic. However, due to the installation of temperature reinforcing, the design is conservative. Reinforcing and concrete stresses are very low when considering the rock to be elastic.

To substantiate the above statement the following studies were performed:

1) The foundation modulus was determined utilizing the expression[1]:

$$k_z = \frac{4\ Gr_o}{1 - \mu}$$

where k_z = The vertical spring constant of a circular base supported on an elastic foundation

$$G = \frac{E}{2\ (1 + \mu)}$$

r_o = Radius of Foundation

μ = Poisson's Ratio

To obtain the foundation modulus, k_z is divided by the area of the circular base to yield

$$k_o = \frac{k_z}{A} = \frac{4\ G}{\pi r_o\ (1 - \mu)}$$

Substituting for G

$$k_o = \frac{2\ E}{\pi r_o\ (1 - \mu^2)}$$

2) The first case examined was that of a rectangular strip loaded with 1.5 times design accident pressure plus dead load using conservative properties for the Dolomitic limestone[2],[4]:

$E = 6.0 \times 10^6$ psi

$\mu = 0$

Applying these values

$k_o = 4370\#/\text{in.}^3$

The "characteristic" λ is defined as:[3]

$$\lambda = \sqrt[4]{\frac{k}{4\,EI}}$$

Where E is the modulus of elasticity of the structural base (concrete), I is the moment of Inertia of the structural base,

and $k = k_o\ b$, (b = width of base)

using base properties

$\lambda = 7.56 \times 10^3\ \text{in.}^{-1}$

Where $\lambda \ell > \pi$ beams may be considered as infinite in length.[3]

Taking the length of beam as being the base diameter

$\lambda \ell = 13.1 \quad > \pi$

The beam was then analyzed as a beam of unlimited length loaded over an area equal to the base diameter with an 80 psi uniform load.

The solution to this problem gives

$$y_c = \frac{q}{2k} \left(2 - D_{\lambda a} - D_{\lambda b}\right)$$

$$M_c = \frac{q}{4\lambda^2} \left(B_{\lambda a} + B_{\lambda b}\right)$$

$$Q_z = \frac{q}{4\lambda} \left(c_{\lambda a} - C_{\lambda b}\right)$$

Where

y_c is deflection of point being considered

M_c is the moment at point being considered

Q_c is shear at point being considered

q is the uniform load

a is distance from point under consideration to end of load

and b is distance from point under consideration to other end of load.

$$B_{\lambda x} = e^{-\lambda x} \text{ Sin } \lambda x$$

$$C_{\lambda x} = e^{-\lambda x} \text{ Cos } \lambda x - \text{Sin } \lambda x$$

$$D = e^{-\lambda x} \text{ Cos } \lambda x$$

Maximum moment occurs at mid-point of load and is equal to 352 in-#/in.

For the area of the mat where there is only temperature reinforcing, the maximum moment would cause a stress of 30 psi in the reinforcing.

The maximum shear would occur at the ends and is equal to 2.64 $^k/$ in. This shear would cause a shear stress in an unreinforced concrete section of 26.4 psi.

3) A second case examined was for the foundation material being less rigid than the concrete base. The model was the same for the first case:

$$\text{Assumed } E_{rock} = 2.6 \times 10^6 \text{psi}$$

$$\mu = 0.$$

For this case, the following were determined:

k_o = 1890lb/in.^{3}

λ = 6.2 x 10^{-3} in.$^{-1}$

M_{max} = 3.66 in-k/in.

Q_{max} = 3.23 ^{k}/in.

S_{rebar} = 312 psi

ν_{conc} = 32.3 psi

4) As a final study, the maximum deflection as calculated in first case was imposed as a settlement of the base mat for the outer portion and a section of the mat was analyzed for this settlement. A 30 foot section was used with fixity at the reactor pit, the remainder cantilevered from the pit.

The resulting moment and shear are as follows:

M = 142 in-k/in.,

q = 396#,

resulting in a rebar stress of 12.2 ksi and a shear stress of 4.0 psi.

From the above, it can be seen that the assumption that a foundation on rock is a rigid unyielding foundation is a valid one and that temperature reinforcing provides much greater resistance than required to accommodate the effects of any elastic deformation of the sub-grade.

References:

1. "Design Procedures for Dynamic Loaded Foundations" by R. V. Whitman and F. E. Richart, Jr. - A.S.C.E. - Journal of the Soil Mechanics and Foundations Division Vol. 93 No. SM6, No. 1967.

2. "Elements of Strength of Materials" by S. Timoshenko and D. H. Young - D. Van Nostrand Company, Inc. 1962.

3. "Beams on Elastic Foundation" by M. Hetenyi - Ann Arbor Press 1955.

4. "Formulas for Stress and Strain" by Raymond J. Roark - McGraw-Hill Book Co., Fourth Edition.

QUESTION 2.6

For the base slab, describe:

(b) State the elastic properties of the bedrock that have been used for the design.

ANSWER

The slab was considered to be resting on a rigid non-yielding foundation, thus no elastic properties were used in the design.

The compressive stress of 118 test cylinders taken from the bedrock on site resulted in an average of 5,250 psi with approximately 90 percent of the tests falling in the range 2100 to 9900 psi.

QUESTION 2.7

With respect to seismic design of the containment, describe:

(a) The general analytical model for the containment including mass distribution, stiffness coefficients, modes of vibration, and analytical procedures for arriving at a loading distribution on the containment structure.

ANSWER

The loads on the containment structure caused by the earthquake will be determined by dynamic analysis of the structure. The dynamic analysis will be made on an idealized structure of lumped masses and weightless elastic columns acting as spring restraints. The model representation is essentially that of a cantilever beam. Since the containment is founded on rock, no translation or rotation of the structure as a rigid body is considered.

The analysis will be performed in two stages: The determination of the natural frequencies of the structure and its mode shapes, and the modal response of these modes to the earthquake by the spectrum response-method.

The natural frequencies and mode shapes are computed from the equations of motion of the lumped masses. These equations are solved by iteration techniques by a fully tested digital computer program. The form of the equation is:

$$(k) \quad \Delta = \omega^2 \quad (M) \quad \Delta$$

(k) =Matrix of stiffness coefficients including the combined effects of shear and flexure.

(M) =Matrix of concentrated masses. Each mass may have up to six degrees of freedom.

Δ =Matrix of mode shapes

ω =Angular frequency of vibration.

The results of this computation are the several values of ω_n and mode shapes $(\Delta)_n$ for n = 1, 2 3... N, where N is the number of degrees of freedom assumed in the idealized structure.

The response of each mode of vibration to the earthquake gound motion is computed by the response spectrum technique as follows:

a) The participation of each mode, P_n is computed from:

$$P_n = \frac{\sum_{m=1}^{N} \Delta^x_{mn} M_m}{\sum_{m=1}^{N} \Delta^2_{mn} M_m}$$

Where Δ_{mn} is the deflection of mass point m in mode n.
Δ^x_{mn} is the component of Δ_{mn} in the direction of the earthquake.

b) The relative deflection of each mass is determined from

$$Y_{mn} = \Delta_{mn} \times P_n \times \frac{S_{an}}{\omega_n^2}$$

Where S_{an} = the spectral acceleration of a single degree of freedom system with a frequency ω_n and damping coefficient, a.

c) In each mode the shear forces and moments are calculated from the deflected shape. These are maximum values of the response in each mode. The total response is computed as the root-mean-square sum of the individual modes. The number of modes to be combined will be determined at the time of final design when the contribution of the higher modes will be investigated. It is expected that only the first three modes need be included but additional modes will be considered if their effect is significant.

QUESTION 2.7

With respect to seismic design of the containment, describe:

(b) The order of magnitude of lateral earth pressure under seismic loading and how this is factored into the design.

ANSWER

The effects of soil structure interaction under seismic loading were investigated. See answer to 2.5(c).

QUESTION 2.7

With respect to seismic design of the containment, describe:

(c) The manner in which damping will be considered in the structural design. Justify the damping values employed for the various components of the structure considering possible cracking and different modes.

ANSWER

Damping will be considered in the structural design as related to the response spectrum curves.

A value of 2% critical damping will be used in the design of the containment building for the design earthquake (smaller) and a revised value of 5% for the hypothetical earthquake (larger). Based on the paper "Design Criteria for Nuclear Reactors Subjected to Earthquake Hazards" by Nathan M. Newmark, a value of 3% to 5% critical damping could be used for ordinary reinforced concrete structures with considerable cracking under a stress of about 1/2 of yield. A value of 7% to 10% can be used for ordinary reinforced concrete at yield stresses.

Atomic Energy Commission TID-7024 also recommends 7% as a reasonable value for concrete structures. Since stresses in the containment will cause cracking at stress levels greater than 1/2 yield point, values of 2 and 5 percent critical damping are justified.

QUESTION 2.7

With respect to seismic design of the containment, describe:

(d) The extent and manner in which the horizontal, vertical, and rocking motions will be considered in the design, and how the corresponding damping will be included. Describe the motion of the structure with respect to ground using the above three components of action.

ANSWER

The ground acceleration has been determined to be 0.1 g applied horizontally and 0.05g applied vertically simultaneously. These values have been resolved as conservative numbers based upon the recommendations from Dr. Lynch, Director of Seismic Observatory, Fordham University. Since the containment is founded on a rock foundation, no rocking will be considered.

	Component	Per Cent of Critical Damping
1.	Containment Structure	
	Hypothetical earthquake (larger)	5.0
	Design earthquake (smaller)	2.0
2.	Concrete Support Structure of Reactor Vessel	2.0
3.	Steel Assemblies	
	a. Bolted or Riveted	2.5
	b. Welded	1.0
4.	Vital Piping Systems	0.5
5.	Concrete Structures above Ground	
	a. Shear Wall	5.0
	b. Rigid Frame	5.0

The response of the containment to the horizontal ground motion is computed and the deflection of the structure from the horizontal motion is shown in the answer to 2.4(b). Deflection response to the vertical and rocking motion are negligible.

QUESTION 2.7

With respect to seismic design of the containment, describe:

(e) The earthquake design response spectra shown in the PSAR have been scaled from the El Centro Spectrum. Indicate the degree to which the validity of this scaling was examined in connection with this site.

ANSWER

The response curves given in Figures 5-7 and 5-8 of the PSAR were developed from the average acceleration velocity displacement curves presented in TID-7024, Nuclear Reactors and Earthquake, for large-magnitude earthquakes at moderate distances from the epicenter. As such the curves are made up of the combined normalized response spectrum determined from components of four strong-motion ground accelerations, El Centro, California, December 30, 1934; El Centro, California, May 18, 1940; Olympia, Washington, April 13, 1949 and Taft, California, July 21, 1952. These curves are scaled by the ratio of intensity of the ground acceleration for the site to the maximum ground acceleration measured for the El Centro California, May 18, 1940 earthquake.

Since no strong motion records are available for the Eastern United States, the method used appears to be the most rational considering the amount of earthquake data currently available. In addition this method is consistent with the procedure being carried out on the majority of the Nuclear Plants presently under construction in the United States.

There is not sufficient data available at this time particularly in the Eastern United States to attempt to correlate specific site conditions to a particular response spectrum.

QUESTION 2.7

With respect to seismic design of the containment, describe:

(f) Discuss the stress levels and loading criteria that will be employed in the design for the design basis earthquake (larger earthquake) and the operating basis earthquake (smaller earthquake) and the limiations on deformations utilized.

ANSWER

Deflections are limited by physical considerations. The location of the interior steel and the distance between the liner and the interior columns determines a maximum inward movement of the wall. The expansion joint in the spent fuel penetration allows for relative displacement between the containment structure and the fuel storage building.

Maximum stress levels employed in the seismic design will be the same as those used for any other loading condition.

The design is based upon limiting load factors which are used as the ratio by which loads will be multiplied for design purposes to assure that the loading formation behavior of the structure is one of elastic, tolerable strain behavior. The load factor approach is being used in this design as a means of making a rational evaluation of the isolated factors which must be considered in assuring an adequate safety margin for the structure. This approach permits the designer to place the greatest conservatism on those loads most subject to variation and which most directly control the overall safety of the structure. In the case of the containment structure, therefore, this approach places minimum emphasis on the fixed gravity loads and maximum emphasis on accident and earthquake or wind loads. The loads utilized to determine the required limiting capacity of any structural element on the containment structure are computed as follows:

i) $C = 1.0D \pm 0.05D + 1.25P + 1.0\ (T' + TL') + 1.25E$

ii) $C = 1.0D \pm 0.05D + 1.0P + 1.0\ (T'' + TL'') + 1.0E'$

Symbols used in these formulae are defined as follows:

C:	=	Required load capacity of section.
D:	=	Dead load of structure and equipment loads.
P:	=	Accident pressure load as shown on pressure-temperature transient curves.
T':	=	Load due to maximum temperature gradient through the concrete shell and mat based upon temperatures associated with 1.25 times accident pressure.
TL':	=	Load exerted by the liner based upon temperatures associated with 1.25 times accident pressure.
E:	=	Load resulting from either design (smaller) earthquake or wind, whichever is greater.
T":	=	Load due to maximum temperature gradient through the concrete shell, and mat based upon temperatures associated with the accident pressure.
TL":	=	Load exerted by the liner based upon temperatures associated with the accident pressure.
E':	=	Load resulting from assumed hypothetical (larger) earthquake.

Load condition (i) indicates that the containment will have the capacity to withstand loadings at least 25 per cent greater than those calculated for the postulated loss-of-coolant accident with a coincident design (smaller) earthquake.

Mathematical solutions of load condition (ii) indicate the containment will satisfy this relation for seismic loads of at least equal to those corresponding to those calculated for the postulated loss-of-coolant accident with a coincident hypothetical (larger) earthquake.

QUESTION 2.8

With respect to liner design, describe:

(k) How the shears, especially those due to thermal expansion and earthquake, will be accommodated. It is noted that the bottom liner is not accessible for inspection during the life of the plant. It is therefore very important to avoid any unnecessary stresses and strains in the botton liner. The arrangement for load transfer through the liner under the bottom of the interior structure should provide for transfer of shears parallel to the liner.

ANSWER

The liner can accommodate any shears it will see due to thermal expansion or earthquake.

An investigation was made on the thermal effects, based on the conservative assumptions that the base mat was fully fixed against any thermal movement thereby restraining the liner from movement. The 3' -0" fill slab was then subjected to thermal growth. No excessive forces were introduced into the liner and the welds on the test channels are sufficient to prevent any shear failure of the test channels from the liner due to movement of the 3' -0" fill mat.

Seismic shear of the interior concrete is resisted by the keying action of the reactor pit and the recirculation and sump pumps in addition to the weld channels. Considerable resistance is also provided by friction between the liner and the 3' slab.

QUESTION 2.8

With respect to the liner design, describe:

(1) Describe the liner arrangement to be used at the base-cylinder to liner juncture, the strain limits imposed at the juncture, and provide an analysis of the capability of the chosen liner arrangement to absorb these strains under design basis accident and earthquake conditions.

ANSWER

The base-cylinder liner juncture consists of a 3/4" plate bent at a 6" radius (see Figures for Question 2.4 a) to provide a smooth transition from the vertical cylindrical plate to the horizontal base plate. The curved plate is anchored to the concrete.

The knuckle was analyzed by conservatively considering two plates at right angles with displacements at the ends equal to the displacements in the wall and slab under the most severe loading condition. The strain limitation was the factored yield strain but the calculated strain was only about 8% of the allowable strain of 95% of yield.

QUESTION 3.1

Justify the type of cement to be used, explain the basis for the selection and describe the user verification testing to be performed.

ANSWER

Type I cement will be used in the containment structure. This normal cement was chosen as an alternate to Type II or III because experience has shown that high early strength cement (Type III) provides excessive heat of hydration and that in similar structures no requirement exists for low heat of hydration (Type II) cement.

All cement will be sampled at the ready-mix plant and tested to conform to ASTM C150 standards.

QUESTION 3.2

Indicate the specifications to be used for the concrete aggregate, and indicate the quality control testing to be performed to assure the conformance to specifications of delivered aggregate. Similarly, indicate specifications and tests for the mixing water.

ANSWER

The fine aggregate and the coarse aggregate, consisting of gravel, crushed stone or slag shall conform to ASTM Specification C33.

Fine aggregate tests to be performed include gradation fineness modulus, specific gravity, unit weight, organic impurities, soundness (5 cycles $Na_2\ SO_4$), silt content and structural strength of sand in relation to Ottawa sand.

Coarse aggregate tests include gradation, fineness modulus, specific gravity, unit weight, soundness (5 cycles $Na_2\ SO_4$), soft particles and Los Angeles abrasion test.

Water used for mixing concrete will be clean, clear and fit for drinking.

QUESTION 3.3

Describe the concrete mix procedures including extent of trial mix testing. Describe the type and usage of admixtures, their compliance with ASTM specifications, and extent of testing.

ANSWER

A testing laboratory will test materials for concrete, design mixes, test check mix at batch plant and job site and test job concrete test cylinders. Design mixes will be checked by the laboratory, including adjustments to obtain a workable mix based on specification requirement, and verified by trial batches and a laboratory test.

The only admixture in the concrete will be PLACEWEL a product of Union Carbide. It is a liquid, water-reducing, air-entraining admixture which enhances the properties of both plastic and hardened concrete. A decrease in water and thus a decrease in paste increases the strength and reduces the shrinkage of concrete. Advantages include reduced bleeding, segregation, and honeycombing, reduced sand streaking in high slump concrete, greatly improved workability particularly in wet harsh mixes, high resistance to freezing and thawing and reduced cracking and permeability.

PLACEWEL will conform with all the requirements of ASTM C494 for Type A water reducing admixture and it contains no calcium chloride.

The mixing of concrete shall be done in a batch mixer of approved AGC type, or in ready-mix equipment conforming to ASTM Specification C94. The volume of the mixed concrete for each batch shall not exceed the rated capacity of the mixer.

The concrete shall be mixed until there is a uniform distribution of the materials and shall be discharged completely before the mixer is recharged.

The PLACEWELL will be tested by virtue of being included in the concrete mix, therefore no further testing other than that stated above will be performed.

Research and testing has been carried out on this product with successful results by such firms as the Portland Cement Association, Johns-Manville, R. E. Davis and various other independent testing laboratories.

QUESTION 3.4

Provide the detailed material selections for containment penetrations, list the corresponding ASTM specifications and indicate NDTT considerations in their selection.

ANSWER

Penetrations

The penetrations conform to ASTM designations as follows:

	Item	ASTM Spec.	Min. Yield Strength (PSI)	Min. Tensile Strength (PSI)	Elongation
1.	Mech. Penetration Sleeve- 12" Dia. & under **	ASTM A333, Gr. 1	30,000	55,000	35% in 2"
2.	Mech.-Over 12" Dia.**	ASTM A201 Gr. B to A300	32,000	60,000	22% in 8"
3.	Rolled Shapes†	ASTM A36, ASTM A131 Gr. C	36,000 32,000	58,000 58,000	20% in 8" 21% in 8"
4.	End Plates	a) ASTM A300 Cl.1 Firebox A201, Gr. B**	32,000	60,000	22% in 8"
		b) ASTM A240 Type 304L†	25,000	70,000	40% in 2"
5.	Fuel Transfer Tube †	ASTM A240 Type 304L	25,000	70,000	40% in 2"
6.	Bellows†	ASTM A312 Type 304L	25,000	70,000	35% in 2"
7.	Elec. Penetrations **	ASTM A333 Gr. 1	30,000	55,000	35% in 2"
8.	Equip. Hatch Insert**	ASTM A300 Cl.1 Firebox A201, Gr. B	32,000	60,000	22% in 8"
9.	Equip. Hatch Flanges**	ASTM A300 Cl.1 Firebox A201, Gr. B	32,000	60,000	22% in 8"

Item	ASTM Spec.	Min. Yield Strength (PSI)	Min. Tensile Strength (PSI)	Elongation
10. Equip. Hatch Head**	ASTM A300 Cl.1 Firebox A201, Gr. B	32,000	60,000	22% in 8"
11. Personnel Hatch**	ASTM A300 Cl. 1 Firebox A201, Gr. B	32,000	60,000	22% in 8"
12. Piping Penetration Reinf.*	ASTM A442, Gr. 60	32,000	60,000	22% in 8"

* The liner plates for the shell, bottom and dome shall be impact tested on a longitudinal section @15 ft-lbs @a temperature 30° below the service temperature of 50°F.

** The equipment hatch, penetration sleeves and personnel lock will be Charpy tested to a minimum of 15 ft-lbs @-50°F.

† No specific NDTT requirements.

QUESTION 4.1

Describe the proposed concrete cover provisions for reinforcing steel for the dome, slab, and cylinder. Include the minimum ACI 318-63 code requirements for comparison.

ANSWER

In the base slab there will be 4-1/2" of concrete cover below the circumferential bars and 6" clear cover below the radial bars.

In the cylindrical wall there will be 3-3/4" cover on the outside diagonal bars and 6-1/4" cover on the inside vertical bars. The hoops will have 8-1/2" cover on the outside bars and 4" cover on the inside bars.

In the spherical dome there will be 3-3/4" cover on the outside diagonal bars and 6-1/8" cover on the inside vertical bars. The hoops will have 9-1/3" cover on the outside and 8-5/8" cover on the inside.

The minimum ACI-318-63 code requirements state that for concrete surfaces exposed to the weather or in contact with the ground 2" of concrete cover is required. The governing requirement is that concrete cover cannot be less than the diameter of the re-bar which in the case of #18S bars is 2-1/4".

From the figures given above it can be seen that minimum code requirements have been met for all cases.

QUESTION 4.2

Discuss the extent of consideration given to the need for Cathodic Protection. What protection will be provided? If soil resistivity surveys have been conducted, report the results.

ANSWER

A Consulting Engineer was hired and a survey made to determine the need for cathodic protection. Based on the survey the Consulting Engineer reported that cathodic protection would not be required for the containment building and none will be provided.

Soil resistivity surveys were conducted with the following results:

Soil resistivity measurements taken in the Unit No. 3 area are plotted against probability in Figure 4.2-1. Note that the mean value of the data obtained is 11,000 ohm-centimeters. Generally, soils possessing a resistivity in excess of 10,000 ohm-centimeters mean are considered to be non-conductive in nature. Data taken in the vicinity of the containment vary from 23,000 to 90,000 ohm-centimeters with a mean of 36,500 ohm-centimeters.

The salt content and therefore the resistivity of the Hudson River water varies greatly on a seasonal basis. The extremes being on the order of 100 ohm-centimeters and 5,000 ohm-centimeters. At the time when soil resistivity was measured in the Unit No. 3 area, the river water resistivity was 1,800 ohm-centimeters.

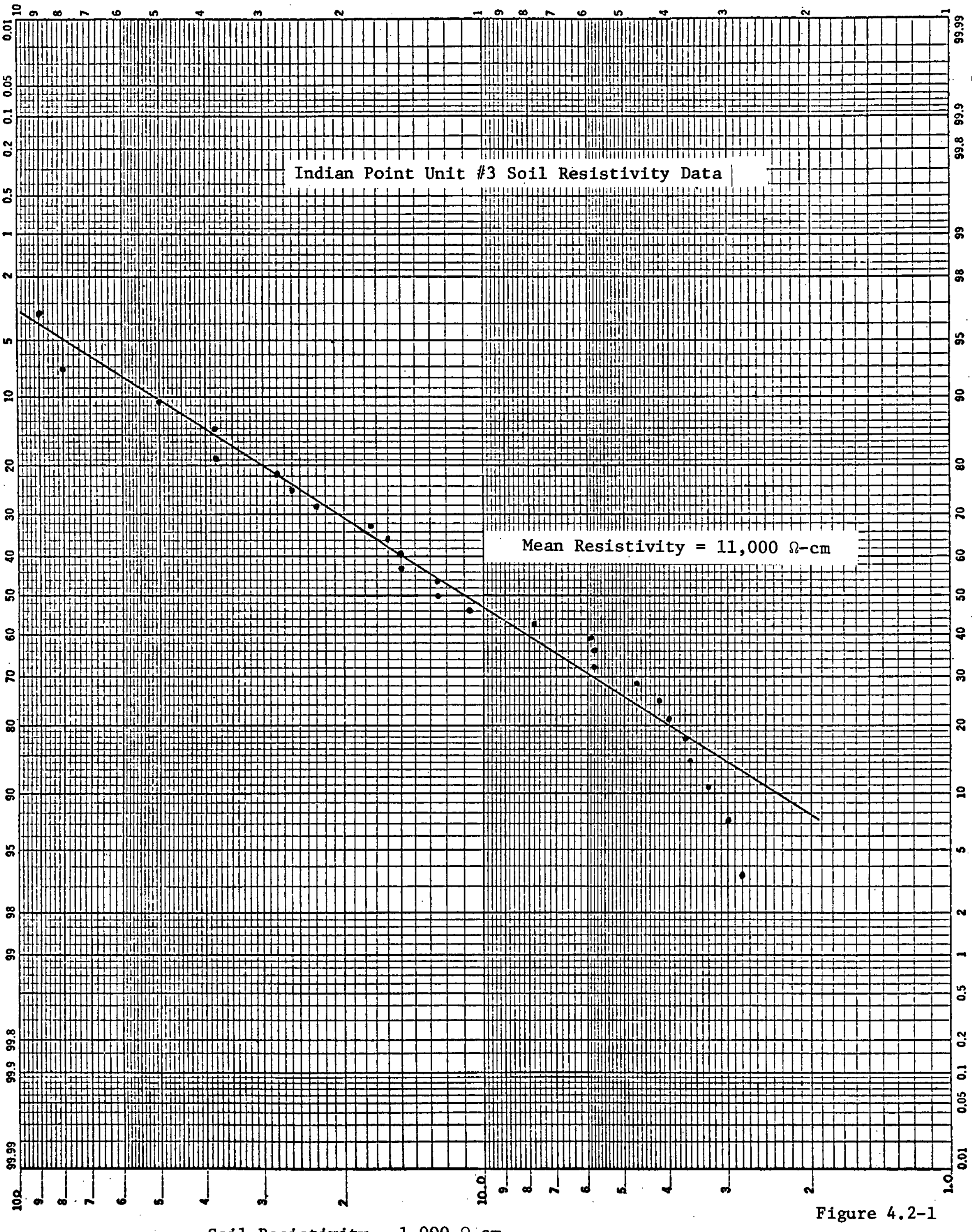

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Figure 4.2-1
Supplement 2

QUESTION 4.3

Discuss the extent to which protective coatings will be applied to the liner.

ANSWER

Inside liner surfaces shall be pickled as necessary for painting with one (1) three mil coat of Carbozinc No. 11 as manufactured by Carboline Company, or approved equal.

Surfaces to be welded shall be free of paint 2" on either side of point of weld. After all welding, etc. the surfaces shall be wire brushed, and touched-up with Carbozinc No. 11.

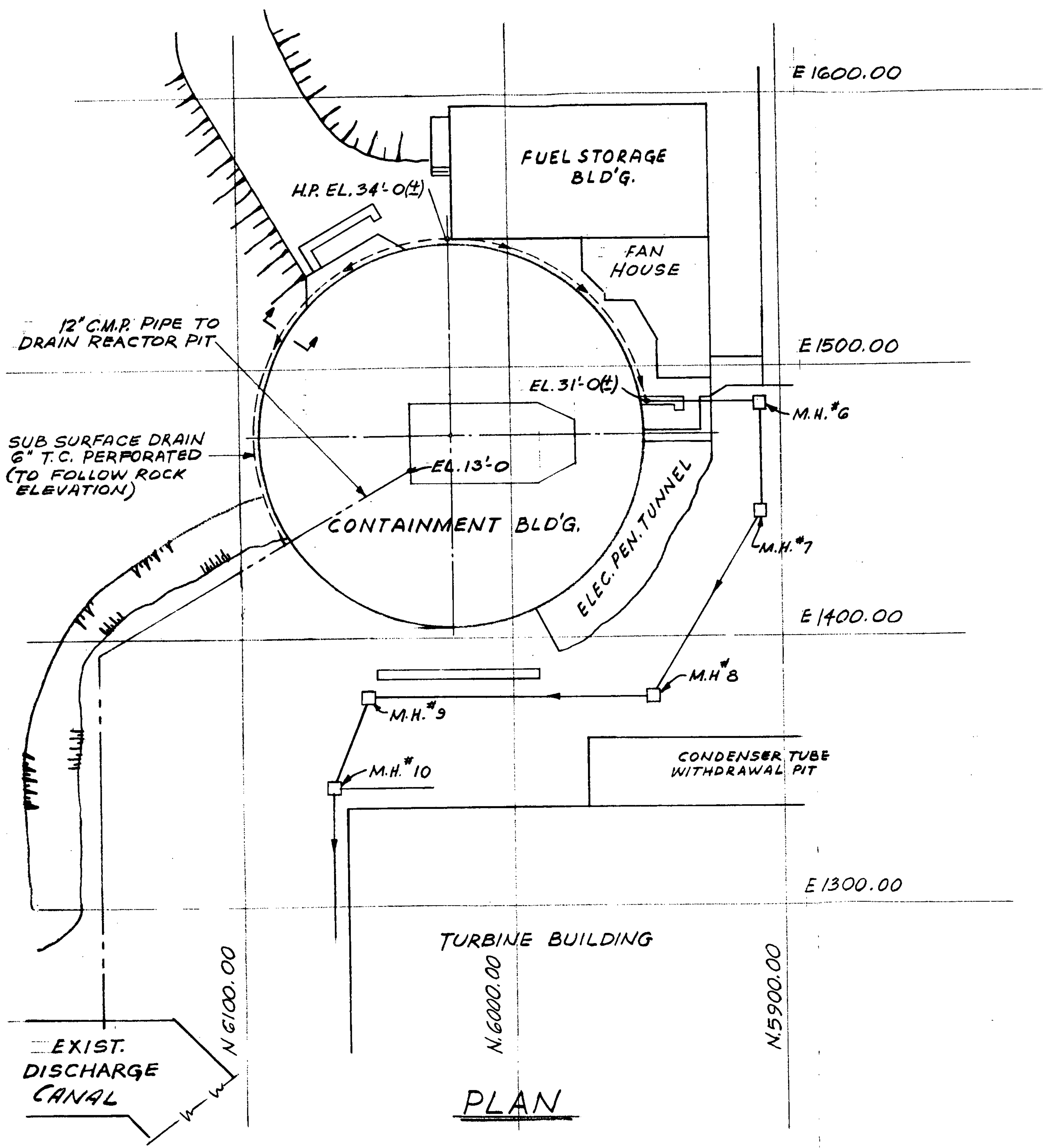
Finish paint with Carboline 368 for the liner shall be applied in accordance with manufacturer's recommendation for a uniform finish.

QUESTION 4.4

Refer to item 2.2 which notes lack of layer of porous concrete between the soil and the containment. Justify the omission of such drainage provisions.

ANSWER

A layer of porous concrete can be omitted because a sub-surface drainage system will be provided around the containment building where the mat is below grade. We are also providing an under drain system as shown in Figure 4.4-1. Since the containment is above the water table, no hydrostatic seepage will occur.



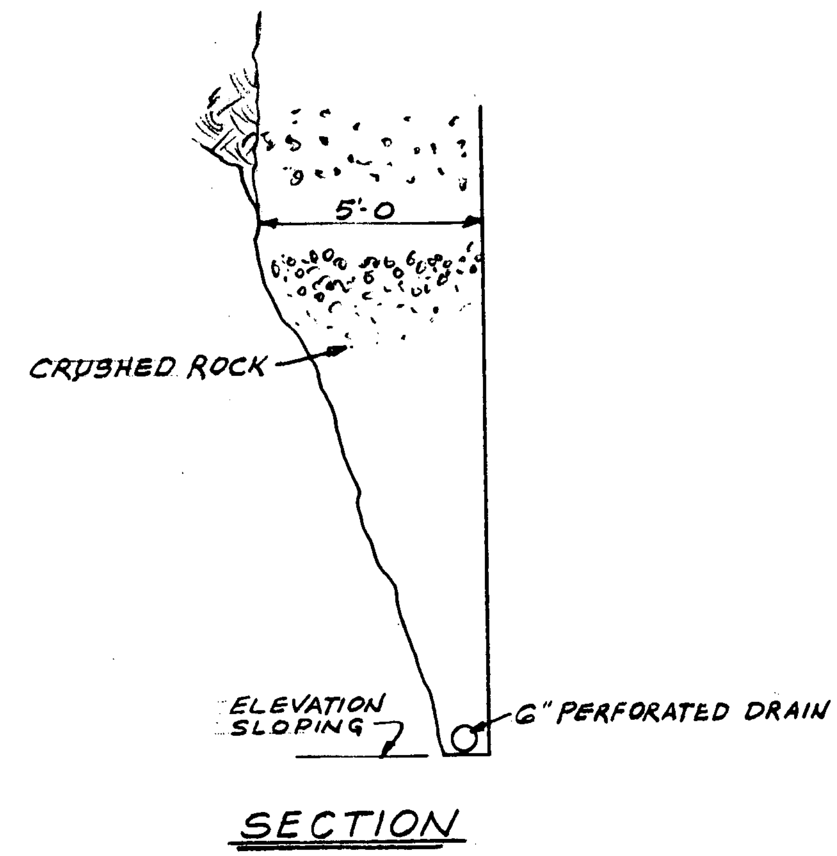


Figure 4.4-1
Supplement 2

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QUESTION 5.1

Indicate the codes of practice that will be followed in the containment construction.

(a) Indicate where and to what extent ACI 301 standard practice for construction will be equaled, exceeded, or not followed.

ANSWER

The ACI Code 318-63 Building Code Requirements for Reinforced Concrete forms the basic code standard for construction of the containment. This code is supplemented by the code provisions of ACI-306-66 for cold weather concreting and ACI 605-54 for hot weather concrete placement. A comparison of augmented ACI Code 318 requirements with those of ACI Code 301 does not reveal any significant differences between the two codes except in those areas relating to mass concrete pours, slump, and increased test cylinder requirements.

The provisions of ACI 301, Chapter 14, governing mass concrete assume concrete pours involving a minimum of concrete reinforcement and minimum pour volume to area ratios. These assumed conditions are not encountered in containment construction. For this reason the provisions of ACI-318 are considered adequate to insure containment integrity.

TABLE 5.1-1

CODES & CLASSIFICATIONS - INDIAN POINT #3 CONTAINMENT

I. STRUCTURAL

	Code	Title
1.	ASTM A-333, Gr.-1	Specification for Seamless and Welded Steel Pipe for Low Temperature Service
2.	ASTM A-181	Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service
3.	ASTM A-300, Cl. 1	Specification for Notch Toughness Requirements for Normalized Steel Plates for Pressure Vessels
	Firebox A-201, Gr. B	Specification for Carbon Silicon Steel Plates of Intermediate Tensile Ranges for Fusion Welded Boilers and other Pressure Vessels
4.	ASTM A-36, Gr. C	Specification for Structural Steel
5.	ASTM A-131, Gr. C	Specification for Structural Steel for Ships
6.	ASTM A-240	Specification for Chromium and Chromium-Nickel Stainless Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels
7.	ASTM A-312	Specification for Seamless and Welded Austenitic Stainless Steel Pipe
8.	ASTM 442, Grade 60	Standard Specification for Carbon Steel Plates with Improved Transition Properties
9.	ASME Boiler & Pressure Vessel Code-Section III	Nuclear Vessels
10.	ASME Boiler & Pressure Vessel Code-Section VIII	Unfired Pressure Vessels
11.	ASME Boiler & Pressure Vessel Code-Section IX	Welding Qualifications
12.	ASTM C-33	Standard Specifications for Concrete Aggregates
13.	ASTM C-150	Standard Specifications for Portland Cement
14.	ASTM C-172	Method of Sampling Fresh Concrete
15.	ASTM C-31	Method of Making and Curing Concrete Compression and Flexure Test Specimen in Field

TABLE 5.1-1 (Continued)

I. STRUCTURAL (Continued)

Code	Title
16. ASTM C-39	Method of Test for Compressive Strength of Molded Concrete Cylinders
17. ASTM C-350	Specification for Fly Ash for Use as an Admixture in Portland Cement Concrete
18. ASTM C-94	Recommended Practice for Winter Concreting
19. ASTM C-42	Methods of Securing, Preparing, and Testing Specimens for Hardened Concrete for Compressive and Flexural Strengths
20. ASTM C-494	Specifications for Chemical Admixtures for Concrete
21. ASTM A-305	Specifications for Minimum Requirements for Deformation of Deformed Bars for Concrete Reinforcement
22. ASTM A-408	Specifications for Special Large Size Deformed Billet-Steel Bars for Concrete Reinforcement
23. ASTM A-432	Specification for Deformed Billet Steel Bars for Concrete Reinforcement with 60,000 PSI Minimum Yield Strength
24. ASTM A-325	Specification for High Strength Bolts for Structural Steel Joints, including Suitable Nuts and Plain Hardened Washers
25. Research Council of Riveted & Bolted Structural Joints of the Engineering Foundation	Specification for Structural Joints using ASTM A-325 Bolts
26. ACI-613	Recommended Practice for Selecting Proportions for Concrete
27. ACI-306	Recommended Practice for Winter Concreting
28. ACI-318, Part IV-B	Structural Analysis and Proportioning of Members Ultimate Strength Design
29. ACI-318	Building Code Requirement for Reinforced Concrete
30. ACI-Code 505	Reinforced Concrete Chimney Design

TABLE 5.1-1 (Continued)

I. STRUCTURAL (Continued)

Code	Title
31. ACI-315	Manual of Standard Practice for Detailing Reinforced Concrete Structures
32. ASME Nuclear Vessels Code	---
33. ASA N6 A	Safety Standards for the Design, Fabrication and Maintenance of Steel Containment Structures for Stationary Nuclear Power Reactors
34. ASA A58.1	American Standard Code Requirements for Minimum Design Loads in Building and Other Structures
35. ---	State Building and Construction Code for the State of New York
36. SSPC-SP-6	Commercial Blast Cleaning

II. NUCLEAR

Code	Title
37. ANS 7.60	Proposed Standard for Leakage Rate Testing of Containment Structures
38. ASTM A-53	Specification for Welded and Seamless Steel Pipe
39. ASTM A-106	Specification for Seamless Carbon Steel Pipe for High Temperature Service
40. ASTM A-333, Gr.-1	Specification for Seamless and Welded Steel Pipe for Low Temperature Service
41. ASME Boiler & Pressure Vessel Code, Section VIII	Unfired Pressure Vessels
42. ASME Boiler & Pressure Vessel Code, Section IX	Welding Qualifications
43. ASTM A-181	Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service
44. ASTM A-300, Cl. I	Spec. for Notch Toughness Requirements for Normalized Steel Plates for Pressure Vessels
Firebox A-201, Gr. B	**Spec. for Carbon Silicon Steel Plates of** Intermediate Tensile Ranges for Fusion Welded Boilers and Other Pressure Vessels
45. USAS B31.1.0	Code for Pressure Piping - Power Piping

TABLE 5.1-1 (Continued)

III. INSTRUMENTATION

46. Carbon Steel Tubing - ASTM A-83, Gr. A

47. Carbon Steel Socket Weld Fittings - ASTM A-105, Gr. II

48. Carbon Steel Compression Tube Fittings - Type C-1018

49. Bellows Seal Needle Valves- ASTM A-276-316SS

QUESTION 5.1

Indicate the codes of practice that will be followed in the containment construction.

(b) Indicate the specific extent to which ASME fabrication standards will be adhered to in liner manufacturing.

ANSWER

The ASME Boiler and Pressure Vessel Code Section VIII will be adhered to in the fabrication of the liner.

QUESTION 5.1

Indicate the codes of practice that will be followed in the containment construction.

(c) Supplement the listing with an additional list of any documents (U.S. Army Corps of Engineers, Bureau of Reclamation, etc.) which may be used as the basis for your specifications to contractors to cover items not recognized by specific codes. State the basis on which these supplementary mandatory specifications will be prepared.

ANSWER

No other documents will be used to prepare specifications.

QUESTION 5.2

Since ASME Standards do not define erection tolerances in sufficient detail to ensure a satisfactory erection of the liner (e.g., they do no cover local curvature deviations), provide the comprehensive set of erection tolerance standards selected for the liner, and show that they identify and satisfactorily limit all inaccuracies likely to occur during erection.

ANSWER

The liner of the completed structure shall be substantially round. The difference between the minimum and maximum inside diameters at any cross section shall not exceed 0.25% of the nominal diameter at the cross section under consideration. Maximum diameter 135'-2", minimum diameter 134'-10" at the cross section under consideration between elevations +43 and +95. Above +95 tolerance shall not exceed .50% of the nominal diameter of cross section under consideration.

The liner shall be erected true and plumb do not exceed 1/500 of height at cross section under consideration with allowance for 2" local buckling in the plates.

Particular care shall be taken in matching edges of cylindrical and hemispherical sections to insure that all joints are properly aligned. Maximum permissible offset of completed joints shall be 25% of nominal plate thickness. Plates buckled beyond acceptable limits shall be cut out and replaced with new plates.

QUESTION 5.3

Based on the preliminary construction schedule, describe the general procedures and sequence of events applicable to construction of the containment. Include excavation, ground water control, base slab construction liner erection and testing, and concrete construction in cylinder and dome regions. Describe the concrete placing and curing procedures, especially at the center of the dome.

ANSWER

Based on the Preliminary Construction Schedule, the following steps are planned for the Vapor Containment Structure:

a. Excavation

- Clear and grub entire area
- Relocate yard drains from Unit 1
- Remove topsoil
- Drill, blast, and excavate to El. +34
- Drill, blast and excavate both sumps - El.22' and El.30'
- Drill, blast and excavate cavity and drainage trench to El. +13'-0".

b. Fill concrete placed to exact grade and keyed for mat pours. 12" CMP placed to remove all water from cavity.

c. Base mat to be placed in nine sections including both sumps and cavity. Pours to be placed in checkerboard fashion allowing curing time between sections. The sump liners and cavity liner will be prefabricated and used as forms for the concrete with internal bracing to maintain shape and alignment.

d. T-bar backing and leveling strips will be anchored (drilled in place anchors) and aligned. Concrete will then be placed flush with T-bar surfaces. Liner erector will then place the bottom liner to and including the knuckle section. Testing will be performed in accordance with the procedures outlined in the response to Question 6.17.

e. Internal mat will be placed and finished to El. 46'-0" including all embedded items.

f. Liner erector will continue wall liner up to El. +88'. A material access approximately 24' x 24' will be left in the N.W. quadrant at El. +46'.

g. All interior concrete up to and including the operating floor will be placed. The Polar Crane will be installed. During this period the exterior concrete will be placed to nearest 5 ft. increment to El. +88'.

h. Liner contractor will return and place liner completely including dome.

i. Concrete for exterior wall will follow liner in 5 ft. lifts. Interior shield walls will be completed using El. +95' equipment hatch for access.

j. Concrete will be placed with four (4) cranes and buckets simultaneously around 400' perimeter in 5' lifts.

k. Dome placing will be in 5 foot lifts using forms to a point 60° from the horizontal. Then four 5 foot pours will be screeded and the final pour will cover approximately 30 feet in diameter and will be screeded. The same placing equipment will be used in the dome as was used in walls.

QUESTION 5.4

Indicate the extent to which splice stagger will be achieved.

ANSWER

In the containment wall splices are shown staggered at 4'-8" with a minimum pattern stagger of 2'-4" except in special cases where physical or layout problems necessitate two adjacent splices. Since this is a rare exception no significant weak point will be created and a satisfactory redistribution of stress would take place in case of a failure.

In the dome at 2'-0" stagger pattern is used throughout for the Cadweld splices as well as the reinforcing splice plates.

QUESTION 5.5

Indicate the extent to which splicing of reinforcing steel will be made by welding. State the location of these welds.

ANSWER

Welding of re-bar will not be permitted.

QUESTION 5.6

Describe the "splicing" of inclined bars, or horizontal stirrups provided to take the radial shears in the base of the walls with the vertical bars. If done by lapping the diagonal bar with a vertical bar or by bending the stirrup around a vertical bar, demonstrate that, despite biaxial tensile stresses in concrete and vertical and horizontal crack patterns, the load in the diagonal bars or stirrups can be transmitted safely to the vertical bars.

ANSWER

In most cases the shear reinforcing is provided by bending the secondary vertical bars across the wall thus having a continuous bar. Stirrup bars are hooked around the vertical bars to achieve mechanical anchorage. A hook is used for all bars which terminate. In no case will any #18 bar be lap spliced.

In the wall and dome the concrete is not relied upon to transfer the load to the vertical bars.

QUESTION 5.7

Describe the procedure for bonding between concrete lifts and indicate the manner in which the lifts will be placed and staggered.

ANSWER

Concrete will be poured in 5'-0" lifts, 360° with no stagger. One week will be allowed to elapse between pours and the surface will be left rough, thoroughly cleaned by air blowdown, and all laitance removed. Joints shall be thoroughly wetted and slushed with a coat of neat cement grout immediately before placing of new concrete.

QUESTION 5.8

Describe those quality control procedures and standard for field welding of liner plate that differ from the general procedures and standards. Include welder qualifications, welding procedures, post-weld heat treatment, visual inspection, magnetic particle inspection, liquid penetrant inspection, and construction records.

ANSWER

Qualification of welding procedures, welders and welding operators shall be in accordance with Section IV "Welding Qualifications" of the ASME Boiler and Pressure Vessel Code.

For the liner complete radiograph shall be made of the first 10 feet of full penetration weld made by each welder or welding operator and a minimum of "spot" radiograph on a 12" film every 50 feet thereafter of weld on side walls and dome, except where back-up plates are used.

All welds for the equipment and personnel hatches shall be 100% radiographed for the first 5' of full penetration weld made by each welder or welding operator and a minimum "spot" radiograph on 12" film every 20 feet thereafter.

When a "spot" radiograph shows defects that require repair, two adjacent "spots" shall be radiographed. If defects requiring repair are shown in either of these, all of the welding performed by the responsible welder or welding operator shall be 100% radiographed to determine end of defect in accordance with ASME Code, Section VIII, Paragraph UW51.

In locations where radiography is not possible, such as floor plates, and lower courses of shell plates where back-up plates are used, the liner fabricator shall weld on a 2" long overrun coupon. The overrun coupon shall be chipped off and marked for location. These coupons are u-bend tested and records maintained in field quality control office.

QUESTION 5.9

Indicate the requirements that will be placed on seam welds to assure adequate ductility.

ANSWER

All seam welds will be made with E70 electrodes having a ductility equal to the ductility of the liner plate. Procedures, welders, and operators are qualified in accordance with ASME Section IX.

QUESTION 5.10

Indicate the applicable ASME or API code sections that will be adhered to in liner erection.

ANSWER

Erection of the liner plate will conform to the applicable portions of part UW "Requirements for Unfired Pressure Vessels Fabricated by Welding" of Section VIII of the ASME Boiler and Pressure Vessel Code. In addition, the qualifications of all welders and welding procedures will be performed in accordance with Part A of Section IX of the ASME Code.

All liner seam welds will be tested in accordance with Paragraph UW51 and UW52 Section VIII of the ASME Code. API code sections have not been specified for liner erection.

QUESTION 5.11

Provide a detailed description of the proposed erection of the bottom liner. Show how a good bearing of the liner on the concrete below will be ensured. State if grouting is to be used and indicate how the liner plates will be fitted to the embedded anchors.

ANSWER

Concrete will be poured to elevation 42'-7 $\pm$ 1/2". A continuous flat plate is anchored to the concrete with a threaded anchor bolt. An angle will be welded to the flat plate and the leveling tee will be welded to the angle. After the leveling tees are set pea gravel concrete will be placed, screeded and steel troweled flush with the leveling tees. This will ensure a good bearing of the liner on the concrete.

The welds at the joints of liner plate panels will occur at a leveling tee, therefore, the liner seam welds will not only join the individual panels but also attach the liner to the top of the leveling tees.

Refer to Figures 2.4(a)-1 and 2.4(a)-2 in answer to question 2.4(a) of Supplement 2 to the PSAR.

QUESTION 6.1

Describe the organization for inspection as requested on Page 3 of our letter of February 19, 1968. Indicate the manner in which inspectors are divorced from construction pressures and the manner in which the engineering design group works with the inspection organization.

ANSWER

Refer to Item 5 of Supplement 1 to the PSAR.

QUESTION 6.2

Indicate the qualification, minimum experience, and authority of inspectors.

ANSWER

Refer to Item 5 of Supplement 1 to the PSAR.

QUESTION 6.3

Indicate the degree to which material preparation and construction activities will be subject to inspector surveillance.

ANSWER

Refer to Item 5 of Supplement 1 to the PSAR.

QUESTION 6.4

Discuss the manner in which records of Quality Control and inspection will be kept.

ANSWER

Refer to Item 5 of Supplement 1 to the PSAR.

QUESTION 6.5

Describe the extent of concrete compression and slump testing to be used. Include the statistical basis for the proposed program and the standards for rejection and pour removal.

ANSWER

One set of six (6) concrete cylinders for compression testing will be made representative of each class of concrete per 100 cubic yards (or portion thereof) placed per day. Three cylinders will be tested at seven (7) days and three at twenty-eight (28) days.

A slump test is made on each truck load of concrete delivered. These tests are based on good quality control practice and past experience.

The results of the compression testing (28-day results) will be evaluated in accordance with ACI 318-63, Section 504.

Individual loads of plastic concrete which do not conform to the specification requirements will be rejected by the Quality Control inspector responsible for field concrete inspection. Rejected loads will be removed from the site.

Items of non-conformance noted at the batch plant will be noted by the Quality Control batch plant inspector and the pour discontinued until the discrepancy is corrected.

When there is a question as to the quality of the concrete in the structure because of strength test failures due to laboratory-cured specimens falling below the specified requirements at 28 days, alternate strength tests in accordance with ASTM C42 or actual load tests in accordance with Building Code requirements ACI-318, may be allowed. Acceptance of the quality of the concrete by these alternate tests will be based on an engineering evaluation and fully documented. Concrete which does not meet the specification requirements or which cannot be tolerated after the engineering evaluation will be removed.

QUESTION 6.6

Indicate the planned program of user testing of reinforcing steel for strength and ductility. Include the statistical basis for the program and the basis for reinforcing steel shipment rejection.

ANSWER

There is no specification requirement for user testing of reinforcing steel on the project. However, as an added quality control measure, one sample per size per heat received is selected at random for physical testing for the #18S, #14S, and #11 bars (those sizes used in the Containment Building and subject to Cadweld splicing). Random sampling will continue up to six samples per size.

Bars are received in bundles segregated by size and heat number. Each bundle is individually tagged with metal tags bearing the heat number. Certified mill test reports covering the size and heat are checked against material received prior to use in the structure.

Heats/sizes represented by user samples which fail to meet specification requirements will be held for resampling and retesting.

Rejected heats will be removed from the project site.

Heats are rejected if they fail to meet the minimum specified yield, ultimate strength, or elongation requirements on the following basis:

> If the original sample fails to meet requirements, the sample size is doubled and tested. If any one of the second sample fails to meet requirements, the sample is again doubled and tested. If any one of the third sample fails to meet requirements, the whole heat is rejected.

The above tests are based on good quality control practice and past experience.

QUESTION 6.7

Indicate the controls that will be provided to ensure that the properly specified reinforcing bars are received, and, if different grades of steel are used, how mistakes will be avoided during erection.

ANSWER

Reinforcing bars received at the project site are checked for grade, size, and heat number. Metal tags on individual bundles and mill markings indicate these identifications and these are checked against results of tests certified on the appropriate mill test reports and results of user testing where applicable.

Only one type of reinforcing is specified and ordered for use on this site.

QUESTION 6.8

Indicate the Calweld splice procedures that will be used, including operator qualification procedures to be followed, inspection and testing, and standards for rejection.

ANSWER

Before any crew can be assigned to production work, they shall demonstrate their ability to produce splices meeting the specification requirements.

Each crew shall be qualified using approved materials and procedures by making five splices of each type and tested to destruction.

Each crew shall be qualified to do specific work only to the extent of having performed satisfactory qualification splices for each category of work; i.e., when qualified for horizontal bar, straight size splices, the crew can make only this type of splice. Any crew having prior qualification for the four types of splices (horizontal-straight, horizontal-reducing, vertical-straight, vertical-reducing), shall be deemed capable of making any type of splice required by the project.

Each crew shall be assigned an identification number and this number shall not be re-issued during the life of the project.

For purposes of this work a crew is defined as an operator who has been qualified in accordance with the above procedure and who shall be assigned a competent helper.

Calweld splices shall be capable of developing in tension at least 125 per cent of the specified yield strength of the reinforcing bar, in accordance with the requirements of ACI 318-63, Section 805-d.

Individual splices which do not meet 125% of yield shall be rejected.

The strength requirements for in-place structures by grade of re-bar, are as follows:

For high-strength bar to ASTM A432, minimum yield strength 60,000 psi, minimum ultimate strength 90,000 psi.

The mean value of the ultimate strength of splices made during any time period shall be equal (as a minimum) to 75,000 psi, plus the standard deviation in strength from the mean ultimate strength. In addition, the mean value of the ultimate strength and the standard deviation shall show, by statistical analysis, that at least 99.0% of all of the splices will have an ultimate strength of 60,000 psi or greater.

Each splice shall be visually inspected by the following procedure. Any splice which, in the judgement of the inspector, does not pass visual inspection shall be cut out and replaced.

a. Bar ends shall be approximately square. They may be torch-cut, sawed or sheared. The cut faces of both re-bar, when inserted into the sleeve, shall be entirely within the specified limits for the size of bar.

b. Bar ends shall be cleaned of dirt, oil, moisture, concrete, or heavy rust, to a degree of cleaniness as represented by heating the end of the bar uniformly to a surface temperature of 200°F to 300°F, power wire brushing to bare metal, reheating to the same temperature range, and hand wire brushing to remove any resulting dust and/or loose material.

c. The re-bars shall be assembled with their sleeve immediately after cleaning and properly aligned.

d. Preheating is not generally required; however, if the air temperature is below 40°F, and/or the humidity is above 80%, the bar ends and sleeve shall be preheated to 100°F in order to remove moisture.

e. If it is necessary to remove a portion of the longitudinal rib on the re-bar in order to fit it into the splicing sleeve, the metal shall be removed by grinding only. In no case shall the entire rib be removed nor shall there by any under-cutting of the rib into the stock material of the re-bar.

f. Properly made splices will have filler metal visible at both ends of the sleeve and at the tap hole in the center of the sleeve.

g. Filler metal will not flow to the very edge of the sleeve due to the gasket action of the asbestos wicking used to seal in the molten filler metal. A recess less than 1/2" will not be cause for rejection.

h. As a result of the Cadweld process, a shrinkage bubble may be visible at the tap hole where the molten metal is introduced and shrinkage fissures and pinholes may be visible at the top of a vertical splice. These casting flaws do not adversely effect the physical performance of the splice and, therefore, do not constitute cause for rejection.

Bars or splices which do not meet the requirements above shall be rejected and removed from the structure.

QUESTION 6.9

Indicate the minimum percentage of Cadweld splices to be tested. A tolerance limiting the off-set of two bars to be spliced should be provided.

ANSWER

For each crew starting work, the following splices shall be cut out of the work on a random basis and tension tested to destruction. The yield strength (if possible), the ultimate strength, and type of failure shall be recorded.

a. For the first fifty splices made, remove and test one out of each five made.

b. For the second fifty splices made, remove and test one out of each ten made.

c. For the next one hundred splices made, remove and test one out of each twenty made.

d. After the first two hundred splices are made, remove and test one out of each one hundred made.

e. Should the splice not meet the strength requirements, then the splice made by that same crew immediately preceding or following the sub-standard splice shall be cut out and likewise tested. If this second test splice meets the requirements, then these two joints may be replaced. These replacement joints may be included in the next grouping from which a random sample may be selected.

   If this second test splice does not meet the requirements, all work by this crew shall be stopped. The five previous splices by the crew shall be cut out and tested. Should any of these five splices not meet the requirements, the crew shall be required to requalify and the Structural Engineer must be able to justify statistically that this crew is capable of doing satisfactory work before executing any further splices. Should the five splices meet the requirements, the reinforcing will be re-spliced. Any one of the re-splices may be selected for a test.

It has been noted that axial misalignment does not affect the integrity of strength of the splice. However, centering of the bars within the sleeve does affect the strength of the splice and in this regard each bar is center-punched 12" from the end and dimensions checked to assure that ends to be spliced are gapped 1/6" to 1/4" in the sleeve and centered to within 1/4".

QUESTION 6.10

Specify the proposed Quality Control Procedures for the strength welds of reinforcing bars to structural elements, such as plates, rings, sleeves, and for occasional strength weld splicing of heavy reinforcing bars.

ANSWER

All reinforcing bars are high-strength ASTM A432 bars and will not be strength-welded or tack-welded except for Cadweld splicing as noted in answers to questions 6.8 and 6.9.

Cadwelding of rebar to structural plate in the dome will be tested in compliance with normal cadwelding procedure. All cadweld splices will be 100 percent visually inspected.

Joining of structural plate and rebar in the dome is by use of cadweld splices which are welded to the plate. These joints are tested in compliance with normal cadwelding procedure. All cadweld splices will be 100 percent visually inspected. The joint between the structural plate and the cadweld sleeve is made in accordance with AWS welding procedure D1.0.

QUESTION 6.11

Describe the reinforcing bar welding procedures and quality control to be used in performing reinforcing bar strength welds. Include bar preparation, user verification testing of reinforcing steel composition, maximum permissible alloy specifications, temperature control provisions, radiographic and strength testing requirements, and the basis for welded splice rejection and cutout. State whether any tack-welding of reinforcing steel will be permitted.

ANSWER

See answer to Question 6.10 of this supplement.

QUESTION 6.12

Indicate the minimum percentage of reinforcing splices to be checked by the welding inspector, using non-destructive inspection methods (X-raying, dye penetrant test, etc.).

ANSWER

See answer to Question 6.10 of this supplement.

QUESTION 6.13

Indicate the controls to be employed in reference to liner plate out-of-roundness and local bulges.

ANSWER

Dimensional checks will be made to assure that the liner plate in the completed structure meets the requirements specified in the answer to Question 5.2 of this supplement.

Any dimensions found outside of the limits shall be cause for rejection and any repair procedures shall be as approved by the Structural Engineer and subject to necessary quality control.

These checks are based on measuring each 9 foot ring in 10° arcs from a reference point at the knuckle.

QUESTION 6.14

Indicate the extent of user verification testing of certified liner NDTT properties, liner thickness, ductility, weldability, etc.

ANSWER

There is no requirement for user verification testing of certified Charpy impact properties, ductility or weldability. Mill test certificates covering these specified properties as well as tensile and chemical properties are required and reviewed for all liner plate.

As liner plates are received, the edges of all plates are checked at four points with vernier calipers to measure liner plate thickness.

QUESTION 6.15

Discuss the seam weld radiography program. Also, provide an evaluation of the proposed liner radiography program to provide assurance that flaws capable of developing into positive leakage paths under design basis accident conditions will not, in fact, exist.

ANSWER

For the liner, 100% radiographic inspection shall be made on the first 10 feet of full penetration weld made by each operator or welder and a minimum of spot radiograph on a 12" film every 50 feet thereafter of weld on side walls and dome, except where backup plates are used.

When a spot radiograph shows defects that require repair, two adjacent spots shall be radiographed. If defects requiring repair are shown in either of these, all of the welding performed by the responsible operator or welder shall be 100% radiographed to determine the end of defect.

The performance and acceptance standards for all radiography shall be ASME Section VIII, Paragraph UW51.

Final assurance as to the integrity of the seam welds under design accident conditions is provided by the containment integrated leak test.

While the liner is not a pressure vessel, industry experience has shown that leaks in pressure vessels normally occur at joints. For this reason and in compliance with current liner fabrication practice, no radiographic examination of liner plate is contemplated.

QUESTION 6.16

Describe the Quality Control Procedures for liner angle and stud-welding.

ANSWER

Where liner bottom welds and floor plate welds are made to angles and tees and radiography is not possible, a 2" long overrun coupon shall be made and destructive-tested. These welds are also vacuum box tested (see response to question 6.17 of this supplement).

Welded studs will be visually inspected and at least one at the beginning of each day's work and another at approximately mid-day will be bend-tested to 45° for each welder. Studs failing visual or bend-testing will be removed.

QUESTION 6.17

Indicate the procedures and criteria for control of seam weld porosity.

ANSWER

All seam weld radiography will be interpreted to ASME Section VIII, Paragraph UW51.

All liner plate welds not accessible for radiographic examination shall be first tested for leak tightness using a vacuum box test. The box shall be evacuated to at least a 5 psi pressure differential with the atmospheric pressure.

After completion of radiography or successful vacuum box test, the welds shall be covered by channels as indicated on the drawings. After completion of the predetermined zone of channel-covered welds, a strength test shall be performed by applying 54 psig air pressure to the channels in the zone period of 15 minutes.

It is intended that the leak tests to be made during liner erection shall indicate no evidence of leakage at liner plate welds and at liner plate and weld joint channel welds.

The zone of channel-covered welds shall be pressurized to 47 psig with a 20% by weight of Freon-air mixture. The entire run of the channel to plate welds shall then be traversed with a halogen leak detector.

The sensitivity of the leak detector shall be 1 x 10^{-9} standard CC per second. The sniffer should be held approximately 1/2-inch from the weld and traversed at a rate of about 1/2-inch/second. The section of any amount of halogen shall indicate a leak requiring weld repairs and retesting.

After halogen test is complete all liner welds not accessible for radiography shall be pressurized with air to 47 psig and soap-tested. Any bubbles indicating a leak shall be repaired and retested. In addition, the zone of channels shall be eld at the 47 psig air pressure for a period of at least two hours with no indication of drop in pressure. Compensation for change in ambient air temperature shall be made if necessary. Where leaks occur, welds shall be repaired by removal of arc gouging, grinding, chipping and/or machining and rewelding.

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